JUN 12 1925

Engineering Library

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Aveling & Porter, Ltd.,
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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See half-page Advert. last week and next week. 2781

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See Advertisement last week, page 13.

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Specification and Workmanship equal to Main Line Locomotives.
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Tubes and Fittings.
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 35, May 22.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

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Worm Wheels cut up to 13 ft. diam
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PRESSURE AIR, STEAM
For Boilers of all types.
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Naval Outfits a Speciality,
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IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 55. 2584

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 2858
See Advertisement, page 51, May 22.

Telegrams: "Epa," London.
Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
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PATENTS. DESIGNS. TRADE MARKS.

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INSULATING FABRICS
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LAND AND MARINE
YARROW BOILERS. 2277

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Walter Somers, Limited,
HALESOWEN. 7116

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS Dumbarton. 2212
See Full Page Advt., page 58, May 22.

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 95, May 22. 8195

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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Undertake SPECIAL MACHINE WORK of any description.
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Works and Offices: 120, Cornwall Street, Glasgow.
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New 300 & 500 B.HP. M.A.N.
STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C 4. 2597

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For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
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See advertisement alternate weeks. 9336

The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. B. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

1925 L. No. 06.

IN THE HIGH COURT OF JUSTICE.
CHANCERY DIVISION
MR. JUSTICE RUSSELL at Chambers.
IN THE MATTER of L. S. STARRETT COMPANY, (Great Britain) LIMITED & REDUCED
and
IN THE MATTER OF THE COMPANIES CONSOLIDATION ACT, 1908.

Notice is Hereby Given that a Petition for confirming the reduction of the capital of the above Company from £60,000 to £32,490 was on the 24th January, 1925, presented to the High Court of Justice and is now pending. A list of persons admitted to have been creditors of the Company on the 30th April, 1925 (the date fixed by the Order in this matter dated the 7th May, 1925), may be inspected at the registered offices of the Company at 35-38-37, Upper Thames Street, or at the offices of Messrs. Grant McLean & Spink, 22, Surrey Street, London, W.C.2, at any time during usual business hours, on payment of the charge of one shilling.

Any person who claims to have been on the said 30th April, 1925, and still to be a creditor of the Company and who is not entered on the said list and claims to be so entered, must on or before the 16th June, 1925, send in his name and address and the particulars of his claim, and the name and address of his solicitor, (if any) to the undersigned at 22, Surrey Street, London, W.C.2, or in default thereof he will be precluded from objecting to the proposed reduction of capital.

Dated this 27th day of May, 1925.
GRANT McLEAN & SPINK,
Solicitors for the said Company. J 177

Crystal Palace School of

Practical Engineering. Founded 1872.
MECHANICAL AND CIVIL ENGINEERING DIVISIONS.
President: J. W. WILSON, M.I.C.E., M.I.M.E.
Principal: MAURICE WILSON, M.I.C.E.
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Students admitted at beginning of any Term.
Of the Students who have passed through the School, many have obtained appointments as Chief Engineers at home and abroad; and upwards of 1400 are employed in Engineering work in various countries.

ROYAL AIRCRAFT ESTABLISHMENT.

An Examination for the Entry of TEN TRADE LADS to the above Establishment will be held on Tuesday, 23rd June, 1925. Application for admission to the examination must be made on the prescribed form, which must be filled in and returned not later than Wednesday, 17th June.

Application forms and the regulations governing the conditions of entry and training of Trade Lads may be obtained by post from
THE SUPERINTENDENT,
Royal Aircraft Establishment,
South Farnborough,
Hants.
or by personal application at the R.A.E. Employment Department. J 160

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc. M. Inst. C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 3689

Examinations for the Civil,

MECHANICAL and ELECTRICAL INSTITUTIONS.—Mr. A. J. ANIDO, B.Sc., Personally Prepares candidates for all examinations of the above Institutions. Arrangements made for business men. —60, Chancery Lane, W.C. Holborn 5776. J 122

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Milgate Building, Manchester. 2863

TENDERS.

TO BUILDERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven a.m., on Tuesday, 16th June, 1925, for EXTENSIONS and ALTERATIONS for ACCELERATED LOW PRESSURE HOT WATER HEATING at Halifax Post Office and Telephone Exchange.

Drawings, Specification, Conditions and Form of Contract, Bills of Quantities, Forms for Tender, etc., may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, etc.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. J 161

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for:—

1. SIX ELECTRIC SCOTCH DERRICK CRANES, 25 and 10 tons, mounted on pontoons.
2. RAILWAY CARRIAGE UNDERFRAMES, BOGIE TRUCKS, etc.
3. WHEELS and AXLES.

Tenders due on the 12th June, 1925, for No. 1, and on the 23rd June, 1925, for Nos. 2 and 3.
Tender Forms obtainable from above. J 172

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for about 190 tons of Mersey Dock Section STEEL TRAMWAY RAILS, 136 lbs. per yard, complete with Fishplates, Bolts, and Nuts.

Drawing may be obtained on application to the Engineer's Office, East Wall, Dublin, between Ten a.m. and Four p.m.

Sealed Tenders, endorsed on the outside "Tender for Rails," should be delivered to the Secretary, Port and Docks Office, Westmoreland Street, on or before Tuesday, 16th June, 1925.

The Board does not bind itself to accept the lowest or an Tender.
Port and Docks Office,
26th May, 1925. J 158

GREAT WESTERN RAILWAY.

The Directors of this Company are prepared to receive

Tenders for Alterations in the GOODS STATION at Paddington.

Plans and Specification may be seen and Forms of Tender and Bills of Quantities obtained at the Office of the Engineer at this Station, between the hours of Ten a.m. and Four p.m.

Tenders, addressed to the undersigned and marked outside "Tender for Alterations, Paddington Goods Station," will be received not later than Ten a.m., on Thursday, the 18th proximo.

The Directors do not bind themselves to accept the lowest or any Tender.

A. B. BOLTER, Secretary.
Paddington Station, London, 25th May, 1925. J 168

METROPOLITAN BOROUGH OF WANDSWORTH.

GAS ENGINE AND PUMP.

The Wandsworth Borough Council invite

Tenders for the Supply, DELIVERY, and ERECTION of a GAS ENGINE and PUMP at Streatham Cemetery, Garratt Lane, Tooting, S.W.

Drawings may be seen upon application to, and Specification, Bill of Quantities, and Form of Tender and Contract obtained from, Mr. ERNEST J. ELFORD, M.Inst.C.E., Borough Engineer, 215, Balham High Road, S.W.17.

Tenders on the form provided, enclosed in a sealed envelope, endorsed "Gas Engine and Pump, Streatham Cemetery," are to be delivered at the Council House, East Hill, Wandsworth, S.W.18, and may be placed by the person tendering in the tender box provided for the purpose not later than Twelve Noon, on Monday, June 15th, 1925.

The Council does not bind itself to accept the lowest or any Tender.

D. A. NICHOLL,
Town Clerk.
Council House,
Wandsworth, S.W.18.
25th May, 1925. J 171

COUNTY BOROUGH OF SOUTHAMPTON.

RECONSTRUCTION OF COBDEN BRIDGE IN REINFORCED CONCRETE.

Tenders are Invited for the RECONSTRUCTION of the above-mentioned BRIDGE having five spans of about 75 ft. each including the provision of a temporary bridge, approaches and all incidental works.

Drawings of the proposed works can be seen at the office of the Engineer for the work, Mr. H. W. FITZSIMONS, B.Sc., M.Inst.C.E., 39, Victoria Street, Westminster. Copies of the Specification, Bill of Quantities and Form of Tender are to be obtained from the Engineer's Office on payment of Five Pounds, which will be returned on receipt of a *bona fide* Tender and return of all documents.

Sealed Tenders, endorsed "Cobden Bridge, Concrete," must be sent to the Town Clerk, Southampton, not later than Ten o'clock in the forenoon on Monday, the 15th day of June, 1925.

The Corporation do not undertake to accept either the lowest or any Tender.

R. R. LINTHORNE,
Town Clerk.
18th May, 1925. J 97

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

1. CYLINDRICAL BUFFERS.
2. SPRING STEEL.
3. MILD STEEL PLATES for Miscellaneous Purposes.
4. COPPER TUBES and LEAD SHEETS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Cylindrical Buffers," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 5th June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of Specification No. 1, 2/6 for each copy of Specification No. 2, and 5/- for each copy of Specifications Nos. 3 and 4.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
21st May, 1925. J 142

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for 30 pairs of MANGANESE CAST STEEL TRAMWAY TYPE RAIL SWITCHES.

Particulars and Drawing may be obtained on application to the Engineer's Office, East Wall, Dublin, between Ten a.m. and Four p.m.

Sealed Tenders, endorsed on the outside "Tender for Points," should be delivered to the Secretary, Port and Docks Office, Westmoreland Street, on or before Tuesday, 16th June, 1925.

The Board does not bind itself to accept the lowest or any Tender.
Port and Docks Office,
26th May, 1925. J 159

HAWARDEN RURAL DISTRICT COUNCIL.

ELECTRICITY UNDERTAKING.

Tenders are Invited for the SUPPLY and LAYING of LOW TENSION UNDERGROUND CABLES and FITTINGS.

Copies of Specification, General Conditions, and Form of Tender obtainable from the undersigned upon payment of a deposit of £1 1s. returnable after receipt of a *bona fide* Tender.

Tenders must be received by me not later than Twelve noon on Thursday, the 11th June, prox.

By Order,
ARNOLD K. WROE,
Clerk to the Council.
Council Offices,
Broughton, Nr. Chester.
May 27th, 1925. J 182

WEST WHARF, CARNWATH ROAD, FULHAM, S.W.6.

DRY DOCKING, ETC., OF PONTOON AND DREDGING WORK.

The METROPOLITAN ASYLUMS BOARD invite

Tenders for the Following WORKS:—

(1) Drydocking, repairing and painting floating pontoon and repairing dolphins and supporting of pier brow; and
(2) Dredging works in the vicinity of the Pontoon.

Specification, conditions of contract and form of tender for each work may be obtained at the Office of the Board, Victoria Embankment, London, E.C.4. Intending Contractors should state, when applying for tender forms, which work it is proposed to tender for.

Tenders for each work, addressed as noted on the forms of Tender, must be delivered at the Office of the Board not later than Ten a.m., on Wednesday, 17th June, 1925.

G. A. POWELL,
Clerk to the Board. J 140

COUNTY OF LONDON.

REPAIRS TO PAVEMENT OF CARRIAGEWAYS OF BLACKWALL AND ROTHERHITHE TUNNELS.

The London County Council invites

Tenders for Repairs to the GRANITE SETT PAVEMENTS and GRANITE CHANNELLING of Blackwall and Rotherhithe Tunnels.

The Specification, Form of Tender, Drawings, &c., may be obtained on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m., on Monday, 8th June, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
Clerk of the London County Council. J 174

APPOINTMENTS OPEN.

General Manager Wanted for JAPANESE and CHINESE Branch of big INDUSTRIAL CONCERN. Must be a man with full knowledge of local conditions and with clear vision, accustomed to handling big job. Knowledge of Engineering an advantage. Good salary according to qualifications.—

Write, giving full particulars in confidence, stating salary required, to G.M. 32, care DEACON'S Advertising Agency, 9, Fenchurch Avenue, E.C.3. J 155

Test Assistants Required in the Metallurgical Department of the Royal Aircraft Establishment for work in connection with investigations in ferrous and non-ferrous materials. Applicants should possess Degree in metallurgy or training and attainments of equal standing. Ex-service men preferred. Starting salary 50s. a week, plus C.S.B., giving a present total of £4 3s. 7d. a week.

Apply, *quoting A* 61, to the SUPERINTENDENT, R.A.E., South Farnborough, Hants. J 180

Applications are Invited for the following POSTS at the Royal Aircraft Establishment:—

Ref. A. 67.—JUNIOR TECHNICAL ASSISTANT, with Technical training to standard of B.Sc. Engineering degree and good knowledge of technical French, for work in connection with airworthiness of aircraft. Experience in administrative work essential; flying experience or general knowledge of aircraft an advantage. Commencing salary £175 a year, plus Civil Service Bonus (giving, at present rate, a total of £278 10s.) on the scale £175-15-£335, plus bonus. Ex-service man preferred.

Ref. A. 68.—TEST ASSISTANT, with Technical training to standard of B.Sc. Engineering degree, required for work in connection with airworthiness of aircraft. Starting salary 60s. a week, plus Civil Service Bonus, giving present total of £4 17s. 3d. Ex-service man preferred.

Write, quoting appropriate reference number, to the SUPERINTENDENT, R.A.E., South Farnborough, Hants. J 179

EGYPTIAN STATE RAILWAYS, TELEGRAPHS AND TELEPHONES.

Applications for the following APPOINTMENTS are REQUIRED and should be addressed to:—
THE GENERAL MANAGER,
c/o The Inspecting Engineer,
Egyptian Government,
Queen Anne's Chambers, Westminster, S.W.1,
not later than June 10th, 1925.

1. ELECTRICAL SIGNAL ENGINEER, at £E. 600 per annum.
2. ELECTRICAL ENGINEER, at £E. 360 per annum.
3. ONE DESIGNER, at £E. 600 per annum, to assist in the Technical Office of Mechanical Dept.
4. ONE MACHINE SHOP FOREMAN, at £E. 600 per annum.
5. ONE JUNIOR DESIGNER, at £E. 360 per annum, to work in the same office as No. 3.

No other remuneration will be paid in addition to the salaries mentioned above.

Appointment will be made on contract for period of two years.

Copy of Contract and list of qualifications required from applicant can be obtained from the Inspecting Engineer's Office. J 164

EGYPTIAN STATE RAILWAYS, TELEGRAPHS AND TELEPHONES.

Applications for the following APPOINTMENTS are REQUIRED and should be addressed to:—
THE GENERAL MANAGER,
c/o The Inspecting Engineer (Egyptian Govt.),
Queen Anne's Chambers,
Westminster, S.W.,
not later than June 10th, 1925.

1. ASSISTANT TO CHIEF MECHANICAL ENGINEER, at £.E. 1000 per annum, to be in charge of the Drawing Office.
2. DESIGNER at £.E. 600 per annum, to assist the candidate referred to above in (1).
3. TWO BOILER INSPECTORS, at a salary of £.E. 480 each.

No other remuneration will be paid in addition to the salaries mentioned above.

Appointment will be made on contract for period of two years.

Copy of Contract and list of qualifications required from applicant can be obtained from the Inspecting Engineer's Office. J 191

THE SUDAN GOVERNMENT, PUBLIC WORKS DEPARTMENT, requires the Services of an

Assistant Controller of Stores and WORKSHOPS. Candidates should have had engineering training originally and have special knowledge relating to motor cars and lorries. Should also have had experience of stores control and be conversant with up-to-date systems and methods. Age 26-33, preferably unmarried. Starting rate of pay about £E. 600 per annum according to age and qualifications.—Apply, by letter, to ADVISORY ENGINEER, Sudan Government, Wellington House, Buckingham Gate, S.W.1, marking envelope "Assistant Controller of Stores." J 131

Wanted at Once, TEMPORARY ENGINEERING ASSISTANTS of good experience in design of docks and heavy masonry; also one experienced in design of reinforced concrete wharves; and another accustomed to steelwork.
Also DRAUGHTSMEN; quick, accurate, with fair general knowledge of Civil Engineering and building construction.
Preference given to ex-Service men.
Apply, giving full particulars of experience, age, salary required, when disengaged, and enclosing copy of recent testimonials, to CIVIL ENGINEER-IN-CHIEF, Admiralty, S.W.1. J 125

Wanted, by Large Swiss Engineering Firm, YOUNG MECHANICAL ENGINEER for Marine Auxiliaries and Turbo-Compressor Estimating and Sales Department. Applicants must have had test-bed and office experience with this class of work and preferably, some marine experience with turbo-machinery. A working knowledge of French or German is desirable.—Address, giving full particulars of qualifications, age, salary expected and copies of three testimonials, J 148, Offices of ENGINEERING.

THE MUNICIPALITY OF SINGAPORE, STRAITS SETTLEMENTS.

SEWERAGE DEPARTMENT—ASSISTANT ENGINEER.

ADVERTISEMENT.

The Municipal Commissioners of Singapore require an

Assistant Engineer for the Sewerage Department, age 28-35, well-educated, of sound constitution, and preferably unmarried. Candidates must be qualified to design and construct sewers and sewerage details, including pumping mains, and must have special knowledge of the latest methods of the purification of sewage to the standard of the British Commission Report. The selected candidate should have had special experience on one or other of the various Activated Sludge Systems at work in this country.

The appointment will be for three years with possible extension. The selected candidate must pass a Medical examination as to his fitness for service in Singapore. A passage will be provided with half salary during the voyage out.

The salary will be 3160 dollars per annum, paid monthly, the value of the dollar being two shillings and fourpence sterling. At this rate the salary would amount to £362. An allowance for such transport as might be required on duty would be granted.

Applications, stating age and place of birth, and giving details of education, training and experience generally, stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. PRINCE & WILLIAMS, M.M.Inst.C.E., 64, Victoria Street, London, S.W.1. Agents to the Commissioners (from whom further information may be obtained), not later than Tuesday, 2nd June, 1925 J 118

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A RATIONAL PILE-DRIVING FORMULA AND ITS APPLICATION IN PILING PRACTICE EXPLAINED.

By A. HILEY, M.I.N.A., Assoc.M.Inst.C.E.

IN the articles published in ENGINEERING in June, 1922, entitled "The Efficiency of the Hammer Blow," the writer demonstrated the relative importance of the several component parts of expended energy, and deduced a rational formula, for general application to pile driving problems, which is as follows :—

$$R = \frac{W \cdot h}{s + \frac{c}{2}} \times \left(\frac{W + P \cdot e^2}{W + P}\right) \quad . \quad . \quad (1)$$

If the condition of the material receiving the blow corresponds to $e = o$, as for instance, where a timber pile or a pile cap of wood has become broomed, the formula takes the more familiar form—

$$R = \frac{W \cdot h}{s + \frac{c}{2}} \times \frac{1}{\left(1 + \frac{P}{W}\right)} \quad . \quad . \quad (2)$$

where R = ultimate resistance overcome in driving, expressed in tons.
W = weight of the kinetic member, or ram, of hammer, expressed in tons.
h = height of free fall of ram equivalent to the actual striking velocity, and expressed in inches.
s = set, or penetration of pile per blow, expressed in inches.
c = temporary elastic compression of pile and cap, expressed in inches, due to the transmission of the stress corresponding to R.
P = weight of pile, which includes all component parts, such as the shoe, helmet and driving cap or anvil, which are set in motion by the hammer blow, expressed in tons.
e = coefficient, depending on the materials receiving impact.

The interest accorded by engineers to the investigations referred to, led to a detailed treatment and proofs of the formula being published in the 1923 Transactions of the Society of Engineers under the title of "The Impact of Imperfectly Elastic Bodies in Pile Driving," which can also be consulted with regard to the principles involved.

As experience has further shown, the methods advocated for estimating the safe bearing loads for piles, and the selection of suitable sizes of hammers for driving, has been accompanied by singularly consistent results. The present article is intended to provide a fuller explanation as to how the formula should be applied to determine the resistance overcome for any given case.

Referring to the formula, where the energy of the blow as expressed by W . h is given in inch-tons, the value of R will be given in tons, or if the kinetic energy, as is usually the case in double-acting hammers, be expressed in inch-lb. the value of R will be given likewise in lb.

The energy given out by the hammer $= W \cdot h \times \left(\frac{W + P \cdot e^2}{W + P}\right)$

$$\text{or} = W \cdot h \times \eta_b$$
$$= (KE) \times \eta_b$$

where (K E) is the kinetic energy of ram at instant of impact.

The work done by this energy consists of two parts, one being the strain energy expended in temporarily compressing the pile and its driving cap; the other being the useful work done in effecting penetration of the pile into the ground $= R \times s$.

When a pile is driven to refusal, the value of s becomes zero, and for this condition the work done is represented by $R \times \frac{c}{2}$

It is often informative to determine the resistance R, at refusal for any size of hammer and pile, and this can be obtained from the equation

$$(KE) \times \eta_b = R_r \times \frac{c}{2} \quad . \quad . \quad (3)$$

From Tables I, II and V, which are given to facilitate our calculations, it will be observed several factors entering into the formula require to be selected with some discrimination; we will therefore, consider these in the order in which they occur.

Energy of Hammer.—The first element which should be a known quantity is the kinetic energy of the ram or kinetic member of the hammer at the instant of impact. The energy represented by either side of the equation in the piling formula must be given in the same units. It is generally found convenient to express the kinetic energy on striking (KE) in the case of drop hammers and single-acting steam hammers, where the comparatively heavy ram is allowed to fall under the action of gravity, in inch-tons.

W = weight of ram, expressed in tons.
H = height of stroke through which the ram is allowed to fall vertically before striking.
h = equivalent height, in inches, of free fall to develop the actual velocity of blow.

Then (KE) = Wh

where h = H, for drop hammer released by monkey trigger.
h = 75 per cent. H for drop hammer actuated by friction winch.
h = 95 per cent. (H − 2^n) for single-acting steam hammers.

In the case of single-acting steam hammers or drop hammers working within guides inclined to θ from the vertical a further allowance would require to be made for the frictional resistance in the guides, taking $\mu = 0{\cdot}1$, and for the reduced component of gravity acting along the direction of the guides. Taking h_1 as the distance travelled by the ram along the guides the accelerating force, and therefore the amount (KE), may be reduced to cos θ − (sine $\theta \times 0{\cdot}1$) of that obtained for a vertical fall. In the case of double-acting steam hammers the energy of blow may be expressed in foot-pounds as given in the particulars furnished by the maker, for hammers of this class. If these energies be used in the formula the work given out must be expressed also in foot-pounds. This can be done by dividing the second part of the expression by 12, thus :—

$$(KE) \times \eta_b = R \times \left(s + \frac{c}{2}\right) \times \frac{1}{12}$$

The energy per blow for a double-acting hammer

$$= W \times St + (A \times m \times St),$$

where W = weight of ram in pounds.
St = stroke in feet.
A = area of piston acted on by steam.
m = mean steam pressure.

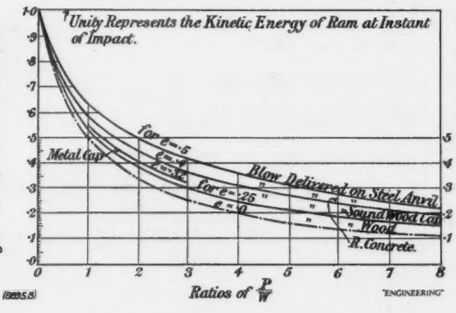


FIG. 1. η_b CURVES OF EFFICIENCY OF HAMMER BLOW APPLICABLE TO ALL CLASSES OF PILE DRIVING.

$$\eta_b = \frac{\text{energy available after impact}}{\text{kinetic energy of blow.}}; \quad R = \frac{W \cdot h^e}{s + \frac{c}{2}} \times \eta_b.$$

The double-acting hammer consists of a comparatively light ram having a short stroke within a heavy casing and giving out its blow on a steel anvil which bears on the head of the pile. The heavy casing serves to resist the force of steam used in giving the ram a high velocity of blow, and, seeing that the limit of A × m is equal to the weight of the casing which can preserve contact on the head of pile, the value of (KE) becomes simply St × (weight of ram + casing).

The equivalent height of free fall of the ram to give the same energy of blow would be $= \frac{St(W + A \cdot m)}{W}$

This generally amounts to 6 ft, as being the equivalent free fall for most hammers of this type, using a usual mean pressure of 70 lb. per square inch, or 90 lb. per square inch boiler pressure. For extractors which hit upwards, the energy of blow is $= St\ (A \cdot m - W)$.

Efficiency of Hammer Blow.—The efficiency of blow expressed by η_b represents the ratio the energy given out after impact bears to the striking energy of the ram.

Let W = weight of the ram.
P = weight of pile + anvil or helmet.
e = coefficient of restitution for the materials under impact.
= 0·5 for steel ram of double-acting hammers striking on steel anvil and driving steel sheet piles or R.C. piles.
= 0·4 for steel ram of double-acting hammers striking on steel anvil and driving timber piles.
= 0·4 for C.I. ram of single-acting hammer striking on head of R.C. pile not fitted with a helmet.
= 0·32 for C.I. ram of single-acting hammer striking on metal cover of wood cap on a Vibro piling tube.
= 0·25 for C.I. ram of single-acting or drop hammer striking on well conditioned wood cap of helmet in driving R.C. pile or directly on head of timber pile.
= 0·0 for a deteriorated condition of head of timber pile or of the wood cap and packing of helmet.

TABLE I.

Efficiency of Blow η_b for Values of e Stated.

Ratio of $\frac{P}{W}$	e=0·5.	e=0·4.	e=0·32.	e=0·25.	e=0.
$\frac{1}{2}$	0·83	0·72	0·70	0·69	0·67
1	0·63	0·58	0·55	0·53	0·50
1½	0·55	0·50	0·46	0·44	0·40
2	0·50	0·44	0·40	0·37	0·33
2½	0·45	0·40	0·36	0·33	0·28
3	0·42	0·36	0·33	0·30	0·25
3½	0·39	0·33	0·30	0·27	0·22
4	0·36	0·31	0·28	0·25	0·20
5	0·31	0·27	0·24	0·21	0·16
6	0·27	0·24	0·22	0·19	0·14
7	0·24	0·21	0·19	0·17	0·12
8	0·22	0·20	0·17	0·15	0·11

The energy available for doing work in sinking and compressing the pile = Wh × η_b; and the work done = R × $\left(s + \frac{c}{2}\right)$

TABLE II.

Dimension of Pile.		Force Transmitted and Resistance in Tons for given Values of p.							
Side.	Area.	p = 500 lbs./sq. inch.		p = 1,000 lbs./sq. inch.		p = 1,500 lbs./sq. inch.		p = 2,000 lbs./sq. inch.	
Inches.	Sq. Inch.	Lbs.	Tons.	Lbs.	Tons.	Lbs.	Tons.	Lbs.	Tons.
10	100	50,000	22	100,000	45	150,000	67	200,000	90
12	144	72,000	32	144,000	64	216,000	96	288,000	128
14	196	98,000	40	196,000	87	294,000	132	392,000	174
15	225	112,500	50	225,000	100	337,500	150	450,000	200
16	256	128,000	57	256,000	114	384,000	170	512,000	228
17	289	144,500	64	289,000	130	433,000	192	578,000	260
18	324	162,000	72	324,000	144	483,000	215	648,000	290

For circular piles the force transmitted will be 78 per cent. of the above.
And for octagonal piles the force transmitted will be 88 per cent. of the above.

then for cases where W is greater than P × e

$$\eta_b = \frac{W + P \cdot e^2}{W + P} = \frac{1}{1 + \frac{P}{W}} + \frac{e^2}{1 + \frac{W}{P}}$$

and for cases where W is less than P.e

$$\eta_b = \frac{W + P \cdot e^2}{W + P \cdot} - \left(\frac{W - e \cdot P}{W + P \cdot}\right)^2$$

The values of η_b for corresponding ratios of $\frac{P}{W}$ and values of e stated covering the general conditions met with, are shown in Table I above, and the curves are plotted in Fig. 1.

The initial energy W.h can also be written (KE)

THE RECONSTRUCTION OF THE TRENT BRIDGE, NOTTINGHAM.

MESSRS. MOTT, HAY AND ANDERSON, MM.INST.C.E., LONDON, ENGINEERS.

Fig. 24.

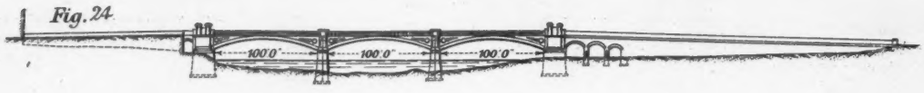


Fig. 25.

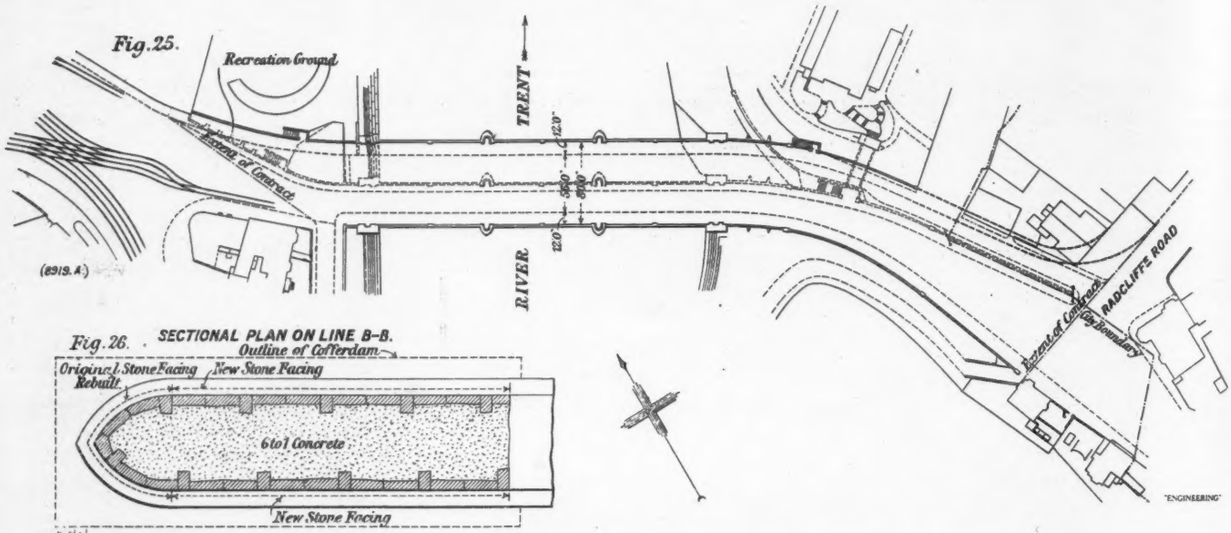


Fig. 26. SECTIONAL PLAN ON LINE B-B.

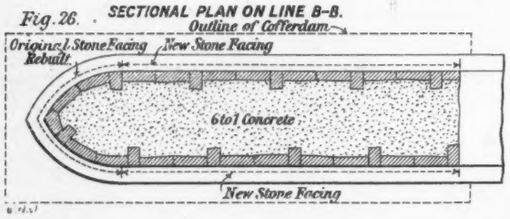
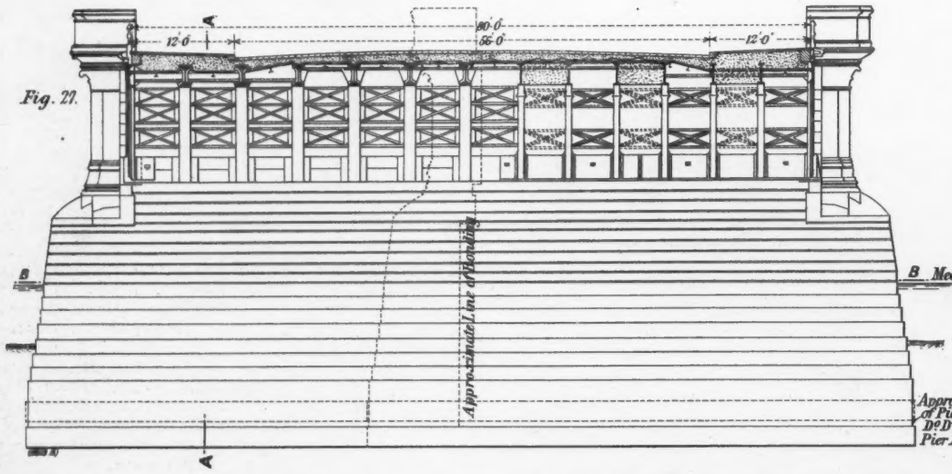
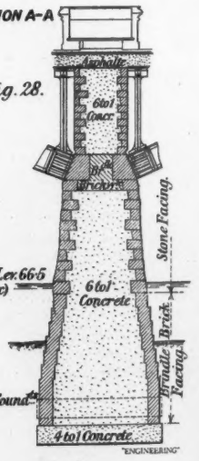


Fig. 27.



SECTION A-A

Fig. 28.



where (KE) is the known striking energy of the ram. The weight of steel anvil blocks for double-acting hammers is given in the makers' particulars of these. For concrete piles the weight of helmet can be taken for piles of 12 in. by 12 in., 14 in. by 14 in., and 16 in. by 16 in. as 6, 7, and 8 cwts. respectively, and for 16 in. diameter by $\frac{3}{4}$ in. Vibro piling tubes the weight of head casting and helmet is 10 cwt.

Resistance Overcome in the Ground.—The resistance offered by the ground to penetration by the pile consists of two parts, one being the direct resistance of the ground to being displaced and the particles compacted by the pile shoe, and the other being the frictional resistance encountered along the surface of the pile in moving relatively to the ground.

The total resistance R may be expressed as a compressive stress transmitted through the material of the sectional area of pile :—

$$R \text{ tons} = \frac{p \times A}{2,240}$$

where p = pressure pounds per square inch on section of pile.
A = sectional area of pile in square inches.

For long parallel-sided piles the centre of resistance may be assumed to act at a point three-fourths of the submerged length below the ground. In the case of tubular piles fitted with an enlarged area of shoe, the resistance to driving may be almost wholly due to direct pressure below the shoe, and therefore the whole length of the pile tube may be considered as subjected to the compressive force R.

In the latter case R ton $= \frac{p \times A_0}{2240}$ where p = pressure in pounds per square inch on the projected area of pile shoe, A_0 = projected area of pile shoe.

The value of the resistance expressed by p is found a convenient criterion of the comparative resistance to driving encountered. Thus, a value of p of 500 lb. per square inch will represent easy driving of a pile.

1,000 lb. per square inch will represent medium driving.
1,500 ,, ,, ,, ,, hard driving.
2,000 ,, ,, ,, ,, very hard driving.

It is useful to express the resistance R transmitted in terms of any value of p desired acting on the sectional area of the pile, and the Table II on page 657, shows the resistance overcome in tons by the penetration of the pile in the ground for given values of p acting on the sectional area of square piles of the dimensions given.

Set per Blow.—The amount of penetration of the pile shoe per blow is commonly measured over a series of 4 or 10 blows, and is used in the formula in conjunction with the temporary compression to determine the work done on the pile, and from this data the resistance overcome can be calculated.

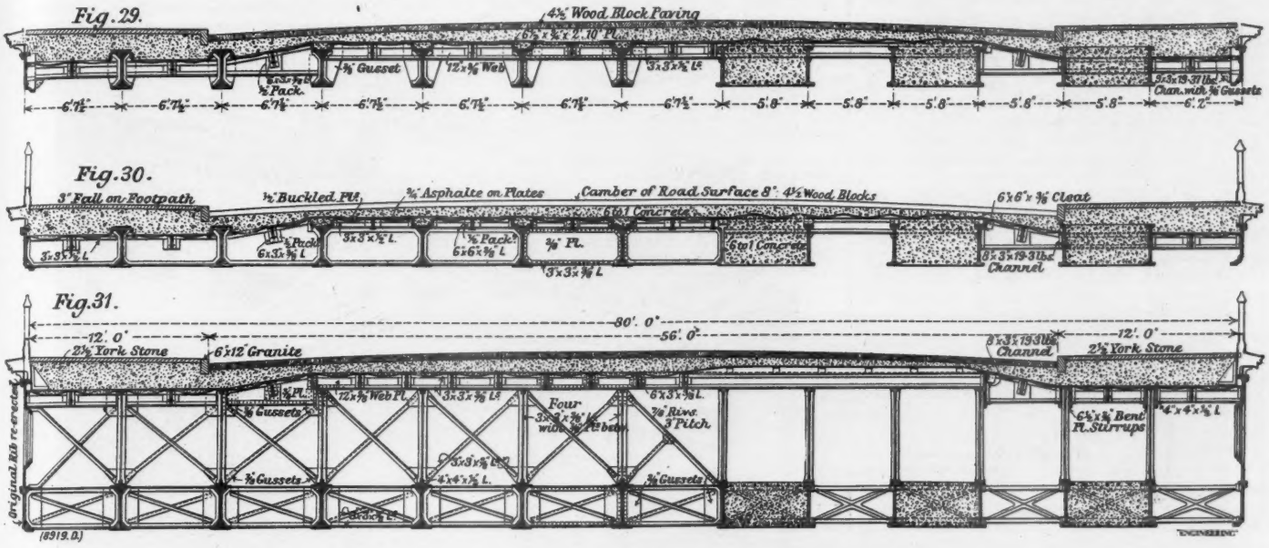
(*To be continued.*)

BRIDGE RECONSTRUCTION WORK OF THE MINISTRY OF TRANSPORT. No. III.

OUR predecessors showed a confidence in the strength and reliability of cast-iron, which so far as structural engineering is concerned, is not shared to-day. Many bridges were erected of this material in days past, which gave most satisfactory service. The old Southwark Bridge, recently replaced, provided a notable instance. The castings for this structure reflected, indeed, the greatest credit on the foundrymen of a 100 years or so ago. At Southwark it was found necessary to replace entirely

THE RECONSTRUCTION OF THE TRENT BRIDGE, NOTTINGHAM.

MESSRS. MOTT, HAY AND ANDERSON, MM.INST.C.E., LONDON, ENGINEERS.



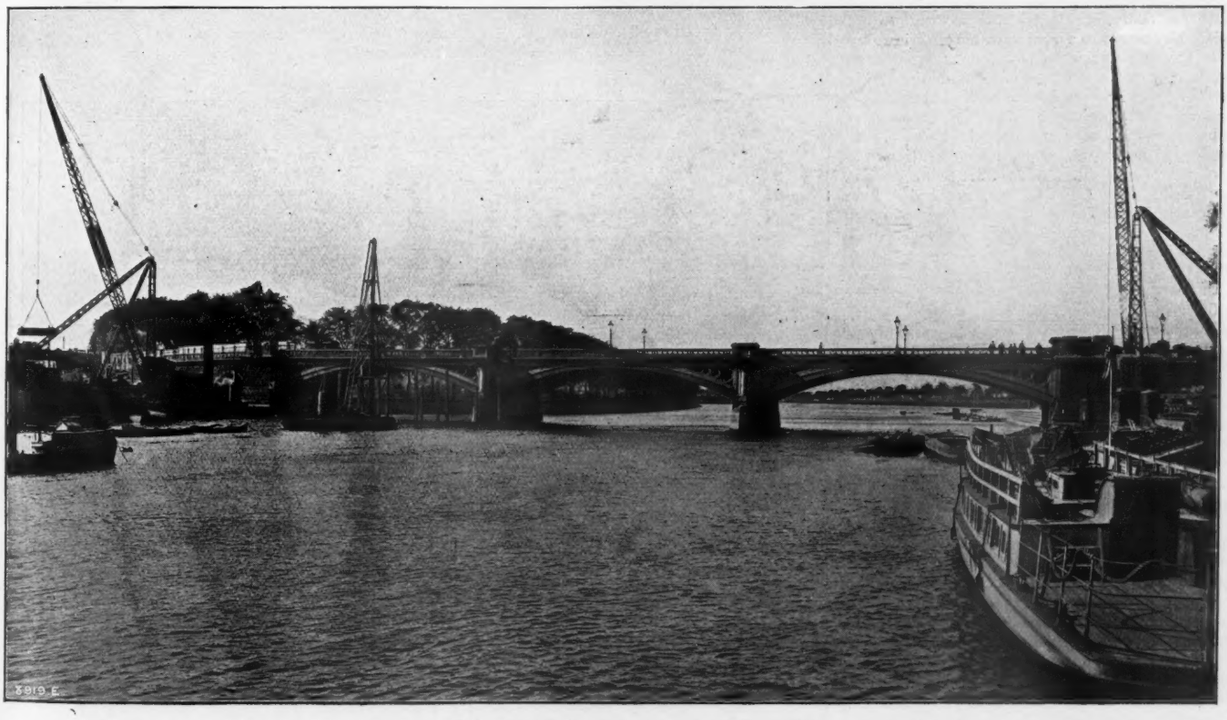


FIG. 32. VIEW OF THE BRIDGE BEFORE THE COMMENCEMENT OF IMPROVEMENT WORKS.

the old structure, in spite of its historic interest, in order to abolish the somewhat severe gradients, which had greatly diminished its practical utility. At Nottingham, where another of these cast-iron arch bridges was erected over the Trent as recently as 1871, a less drastic procedure has been practicable, and we illustrate in Figs. 24 to 34, the improvements which with the aid of the Ministry of Transport are now being carried out to the designs of Messrs. Mott, Hay and Anderson, MM.Inst.C.E., Westminster.

From a note, for which we are indebted to Mr. T. Wallis Gordon, the City Engineer, it appears that the existing bridge is the fourth of a series erected at the same site, which has probably been a recognised crossing point since, perhaps, pre-historic times. The first bridge was erected here by King Edward the Elder in 924, and then replaced by a stone bridge in the reign of Henry II., the date locally accredited to its erection being 1156. Damage by flood and civil wars necessitated a new bridge, which in its final form had 17 arches, varying in width from 17 ft. 6 in. to 21 ft. 6 in. This became markedly inadequate during the 'Sixties of last century, and was accordingly replaced by the existing structure which was built to the designs of Mr. M. O. Tarbotton, M.Inst.C.E. The contractors were Messrs. Andrew Handyside, and the total cost inclusive of approaches was about 36,000*l*.

As shown in Fig. 24, the bridge has three arch spans, each of 100 ft. in the clear with a rise of 11 ft. at the crown. The width of the roadway was 40 ft. between parapets, and this roadway was carried by six intermediate cast-iron arched ribs, in addition to one of more ornate design under each parapet. The width of the carriage way was 27 ft. and there were two side paths each 6 ft. 6 in. wide. An excellent view of the structure as originally erected, is reproduced in Fig. 32 above, and its pleasing appearance affords conclusive evidence that its designer was an artist as well as a highly-competent engineer. The abutments, piers and approach walls are faced with Millstone grit from Whatstandwell quarries, Derbyhire,

The bridge gave excellent service for many

decades, but as the sketch-plan reproduced in Fig. 25 shows, it formed a veritable bottle-neck between two much wider approach roads. The steady increase in the density of traffic during recent years has emphasized the inconvenience thus arising.

The press of traffic has for some time been very considerable. Several main roads connecting Leicester, Lincoln, Newark and Grantham converge on the bridge, which has moreover to take the "gala" traffic to the Notts County cricket ground, and to the ground of the Notts Forest Football Club. At the finish of a football match, the congestion is now so great as to delay ordinary traffic for periods of half-an-hour.

It is not, however, only the density of the traffic that has increased, but also the weights passing over our highways, and it has accordingly been deemed advisable to widen the bridge by the addition of new arch ribs, and to stiffen the older portion by embedding the cast-iron arches in reinforced concrete. At the bridge site, the Trent is a shallow river, with but a moderate current. Solid sandstone rock is met with a few feet below the river bed, so that the widening of the piers and the joining-up of the new work to the old presented a comparatively simple problem, the foundations being laid dry by cofferdams.

The masonry of the old piers has been taken down on the projecting down-stream face of the piers, as indicated by the dotted lines in Fig. 27. The face stones removed were all numbered, and have been used to form the down-stream face of the extended pier. In most cases, they were found to be in excellent condition, but individual units had weathered badly, and these have accordingly been replaced by new stones from the same quarries. The latter have also furnished the stone required for the flanks of the extensions. The foundations being rock, as already mentioned, there will be no danger of unequal settlement, and in a short time it will probably be impossible to distinguish the new masonry from the old. A sectional elevation of the new work is reproduced in Fig. 28, and a sectional plan in Fig. 26. From these it will be seen that the 6 to 1 concrete, constitutes the heart of the pier. The stone facing commences at just below low-water level, being replaced by brindle brick where not exposed to view.

The new arch ribs are of steel. They are spaced at 6 ft. 7½ in. centres, and are 2 ft. 6 in. deep at mid-span, and 3 ft. deep at the springings. The webs are ⅝ in. thick, and as can be seen in Fig. 27, are well stiffened at the springings, so as to ensure an even distribution on the latter of the arch thrust. The flanges consist of 16-in. by ⅝-in. plates, secured to the webs by 4-in. by 4-in. by ⅝-in. angles. They follow in outline the existing cast-iron arches, and it may be added that the old parapet arch and parapet are to be re-erected so as to form the down-stream face of the widened structure.

The roadway is to be carried on ½-in. buckle plates, protected with ¾-in. of asphalte, and filled in with concrete to form a foundation for wood pavement 4½ in. thick. Typical sectional views are reproduced in Figs. 29 to 31, page 659. Provision has had to be made under the path ways for various water, gas, electric and telephone mains. The steel work has been designed for the standard loading of the Ministry of Transport, particulars of which were given in the first article of this series, page 250 *ante*.

The widened structure will provide a carriageway of 56 ft. between kerbs, and as shown there will be two 12-ft. pathways.

Sections through the existing metal work are represented on the right of Figs. 29 to 31. The roadway of the existing bridge is carried on bent plates, riveted to inverted tees. As will be seen, the construction is very shallow, but it has stood up well, as indeed have also the cast-iron arches. These are of 1¾-in. metal with upper flanges 7 in. wide and 9 in. bottom flanges and weigh about 25 tons each. Under heavy modern concentrated loads, these ribs are subject to tension, and hence it has been deemed advisable to fill in concrete between them in the manner illustrated in Figs. 29 to 31, page 659. The additional dead load thus imposed will of itself suffice to eliminate these tensional stresses, but at the same time, it has been considered advantageous not to confine the concrete to this passive *role*, but by reinforcing it with steel rods to develop fully its own strength as an arch. The filling will, of course, also greatly stiffen the cast-iron ribs, considered in the light of compression members. This re-inforcement work will not be commenced until the completion of the widening. The traffic will then be diverted wholly to the widened section, so as to reduce to a minimum the vibration experienced by the concrete during its setting and hardening.

As matters stand to-day, the whole of the masonry has been completed up to the level of the springings, and the erection of the steel work is in progress. The type of scaffolding used as centres is shown in Figs. 33 and 34, an early stage being represented in Fig. 33, whilst Fig. 34 shows three of the ribs in place.

The contract for the work was let early last year to the Cleveland Bridge and Engineering Company, Ltd., of Darlington, whose tender amounted to 78,709*l*., of which the Ministry of Transport will provide 47,226*l*. Auxiliary works will bring the total cost to approximately 120,000*l*.

RECONSTRUCTION OF THE TRENT BRIDGE, NOTTINGHAM.

MESSRS. MOTT, HAY AND ANDERSON, MM.INST.C.E., LONDON, ENGINEERS.

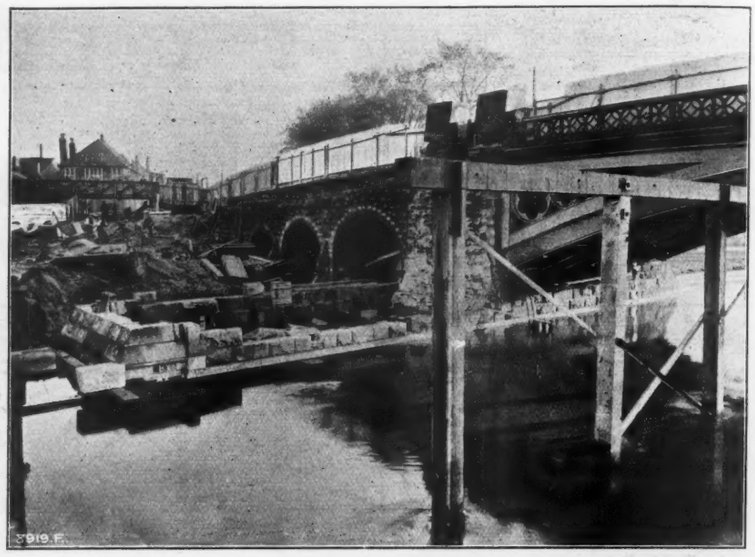


FIG. 33. FIRST BAY OF FALSEWORK FOR SUPPORTING NEW RIBS DURING ERECTION.

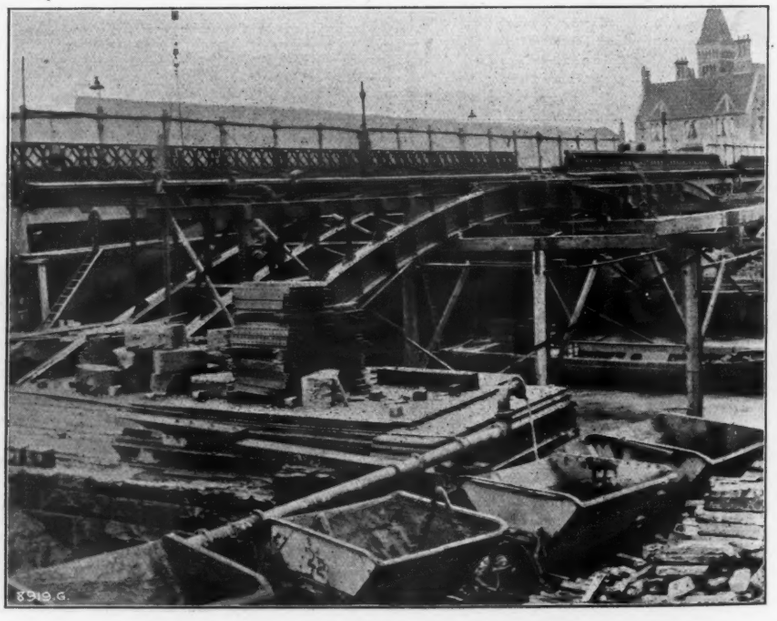


FIG. 34. THE ERECTION OF ARCH RIBS IN PROGRESS.

AUSTRALIAN TRADE.—It is announced that the total values of the goods imported into and exported from Australia during the month of March, 1925, amounted to 16,683,453*l*. and 15,658,146*l*. respectively.

WIRELESS TELEVISION.

THE possibility of rendering objects and events simultaneously visible at a distance of some hundreds, or even thousands, of miles from the place where they are located or taking place, presents a particularly fascinating problem to the inventor, both on account of its extreme difficulty and from the fact that its accomplishment would doubtless bring ample reward. We should regard the problem as completely solved if it were possible to produce in London, say, an image similar to that seen in the camera obscura or on the focusing screen of a photographic camera, of an event taking place in New York, the image showing moving and other objects in their true natural colours, and in their correct relative positions. This is, of course, a very different matter from the transmission of photographs and other pictures over a land line or by wireless telegraphy, which has already attained some measure of success, although, as far as we are aware, it is not regularly practised. Whether true wireless television, as defined above, will ever be possible the future must decide, but an interesting step in the direction of its accomplishment, and one which appears to be worthy of placing on record, has recently been made by Mr. John L. Baird, whose laboratory is at 22, Frith street, London, W.1.

Mr. Baird has been able to produce a crude image of a brightly-illuminated simple object on a screen in one room without any direct connection between the screen and the transmitting apparatus in an adjoining room. The results are admittedly very imperfect, and this, to some extent, may be due to the rough character of the apparatus used, which has been made up by the inventor himself without the assistance of a professional instrument maker. Doubtless by using more accurately made apparatus and by making certain modifications in the system which the inventor has in mind, considerable improvement in the results would be effected, and, in any case, with the early history of the telephone, phonograph and wireless telephony in mind, sympathetic consideration may well be given to the early attempts at development.

The apparatus, in its present form, is illustrated by the photographs reproduced in Figs. 1 and 2, which show the transmitting and receiving instruments, respectively. The transmitter comprises a disc carrying 16 lenses arranged with their optical centres in two spiral curves, as will be clear from Fig. 1, and the body, the image of which is to be transmitted, is placed in front of this disc and very brightly illuminated by the light from a gas-filled lamp. Behind the disc is a light-sensitive cell, placed so that a properly-focused image of the brightly-illuminated body is formed in the plane of the cell by the lenses mounted on the disc. The latter is rotated at about 300 r.p.m. and, as the lenses are mounted at different radial distances from the axis of rotation, it follows that two series of adjacent strips of the image are passed over the cell for each revolution of the disc—one series being formed by each of the two groups of lenses.

Between the lens-carrying disc and the light-sensitive cell is an independently rotated disc formed with a number of radial slots, after the manner of an armature stamping, and the object of this slotted disc, clearly shown in Fig. 1, is to cut up the strips of the image formed by the rotating lenses into small rectangular elements. Each element has a separate and distinct effect on the light-sensitive cell, and each effect is transmitted independently and re-combined, as will be described below, in order to reproduce the complete image at the receiving end of the apparatus. It may, however, be pointed out now that, with the apparatus as at present constructed, the eight strips are each divided into 50 elements, so that the complete image is composed of only 400 elements; any fine detail is, therefore, lost and the main characteristics of the transmitted object are indicated by stepped boundaries. An obvious improvement would be greatly to reduce the size and increase the number of the elements forming the image, and this will be done as soon as possible, although the inventor is of the opinion that a recognisable image of a human face can be produced with only 1,000 elements, using accurately constructed apparatus.

The method of transmission and reception is briefly as follows: The light-sensitive cell is connected in series with a battery and the current fluctuations caused by the rapid changes in the resistance of the cell as the intensity of the light falling on it varies, are amplified by a three-stage transformer-coupled valve amplifier, giving a current with an average value of about 15 milli-amperes. For transmission to a distance, the amplified currents would be used to modulate a continuous wireless wave by the method usually employed in wireless telephony, but, as at present arranged, the circuit carrying the fluctuating currents is inductively coupled to another containing a neon lamp. The light emitted by the latter, which fluctuates in accordance with the current variations in the transmitting circuit, is directed on to a translucent screen, but between the lamp and the screen a slotted disc, seen in Fig. 2, is rotated synchronously with the lens-carrying disc at the transmitting end. The positions of the slots in the disc at the receiving end correspond with those of the lenses in the disc of the transmitter, so that strips of light which sweep across the receiving screen vary in intensity in a similar manner to that of the light falling on the sensitive cell. The strips, it will be understood, have been cut up into elements by the interrupter at the transmitting end, and as the elements appear on the screen in very rapid succession and in their correct relative positions, an image of the body at the transmitting end is reproduced in monochrome on the receiving screen within the limits of accuracy above explained. Slots are used in the rotating disc at the receiving end merely for cheapness and simplicity, but the brightness of the image on the screen would obviously be improved if the slots were replaced by lenses.

Various methods of synchronising the rotating discs at the transmitting and receiving ends are possible, but the inventor actually uses for the purpose a wave of comparatively low frequency produced by a small generator driven from the shaft on which the lens-carrying disc at the transmitting end is mounted. This wave would be superimposed upon that resulting from the high-frequency current fluctuations produced by the light-sensitive cell and transmitted on the same wireless carrier wave. At the receiving end, the two frequencies would be separated out and amplified by known methods, the high-frequency wave being applied to the neon lamp and the low-frequency wave being used to control the speed of the motor driving the rotating disc.

In conclusion, it is perhaps hardly necessary to

FIG. 1. TRANSMITTING APPARATUS.

FIG. 2. RECEIVING APPARATUS.

point out that the exact synchronisation of two rotating bodies separated by some hundreds of miles is itself no easy matter, although it constitutes only one of the side issues in the whole problem of wireless television. A solution to the latter, however, even if less complete than that defined above, would be of very great scientific interest and probably of considerable commercial importance, and this is sufficient reason for giving some consideration to any serious attempt to find one.

THE ELECTRIFICATION OF THE IRISH FREE STATE.

IN the summer of 1918 the Board of Trade appointed a committee to examine and report upon the water-power resources of the United Kingdom, and the extent to which they could be made available for industrial purposes. The reference was subsequently extended to include the consideration of the steps that should be taken to conserve and utilise those resources for all purposes, and immediately after the armistice the Board further appointed a sub-committee, with Sir John Purser Griffith as chairman and Dr. H. H. Jeffcott as secretary, to examine and report on the subject so far as it affected Ireland. Inland navigation and drainage problems have been more thoroughly investigated in Ireland than in any other part of the United Kingdom, but the present was the first enquiry that had been made into water power, and the sub-committee made detailed investigation into four of the most promising sources, besides enumerating a number of others that in their judgment deserved immediate examination. Most of these sources of power were in various parts of the territory that is now the Irish Free State. The enquiry was concluded and the report submitted in December, 1920.

Owing presumably to the change in the political constitution of the country, no effect appears to have been given to the recommendations that this committee was led to make as the result of its two years' investigations; but at the beginning of last year proposals were made to the Government of the Irish Free State by an eminent German electrical firm, Messrs. Siemens-Schuckert, who submitted a tentative plan for electrifying the entire country from a hydro-electric station to be constructed on the Shannon near Limerick. After a few weeks' negotiation, these proposals were made the basis of a contract, in pursuance of which Messrs. Siemens-Schuckert made during the summer of last year extensive field surveys and other investigations, and submitted plans and estimates for carrying out their scheme with such modifications as their further enquiries had suggested. In September last the Irish Free State Government referred the report in which Messrs. Siemens had embodied their scheme to a panel of Scandinavian and Swiss experts, who during the next few weeks made an inspection of the river and a large number of towns and villages, and at the beginning of December drew up their report on the scheme, giving it their general approval, subject to certain modifications.

The Government has now published the report of Messrs. Siemens-Schuckert, omitting the constructional drawings by which it is stated to have been accompanied,* and that of the experts,† and is introducing legislation with the object of putting the scheme into force. Messrs. Siemens-Schuckert's report sets out in considerable detail the data on which it has been prepared, and the methods of calculation and construction that have been or are to be adopted, and for these reference must be made to the original. The omission of the drawings makes it impossible to follow the exact works that are intended to be carried out, but enough is described to exhibit the scheme as being among the most remarkable projects for engineering works with an economic purpose that a responsible authority has ever adopted. It may be of interest, therefore, to describe it in general outline, with such account of its details as may suggest its scope. For the sake of clearness it will be convenient to deal with the unmodified Siemens-Schuckert scheme, indicating subsequently the effect of the alterations suggested by the experts.

Put shortly, the proposal is to electrify all parts of the Irish Free State from a single hydro-electric power station just above Limerick, utilising for the purpose the power of the Shannon from Killaloe, and the storage accommodation, more or less modified, of the lakes on the course of the river. The scheme is intended to be carried out in a first stage of partial development, with an installed output of 75,000 h.p., and a later stage of full development, providing an installed output of 165,000 h.p. or possibly more, which is to be undertaken when the prospect of a sufficient demand has arisen. The catchment area of the Shannon covers 4,016 sq. miles, with an average rainfall of 37¼ in., of which about three-fourths are discharged into the river; and according to daily gaugings taken over 30 years from 1893 this gives an average of 244 cub. m. per second,* with a maximum of 918 cub. m. per second and minimum 25·4.

Fig. 1 shows the profile of the Shannon, with the present levels and locks and the position of the chief points along the river, and Fig. 2 the general plan. In the partial development it is estimated that a storage of 324,000,000 cub. m. will be required, including an "iron ration" of 73,000,000 cub. m., to be used only at the end of a very dry summer, a total that is provided in the three largest lakes—Lough Allen, Lough Ree, and Lough Derg—by the difference between high- and low-water levels, provided that the level of Lough Derg is sunk 2 ft. In the full development the lakes will be raised above their present maxima by 9·66 ft., 3·92 ft., and 6·92 ft., respectively, and a total storage capacity of 827,500,000 cub. m. will be provided.

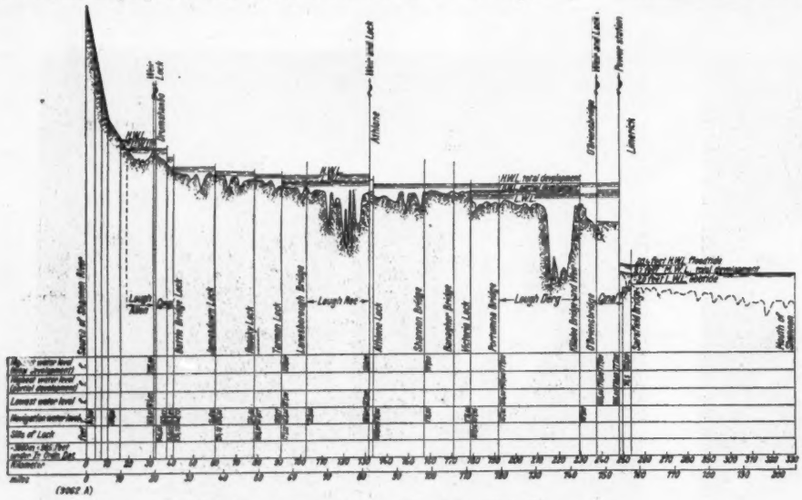
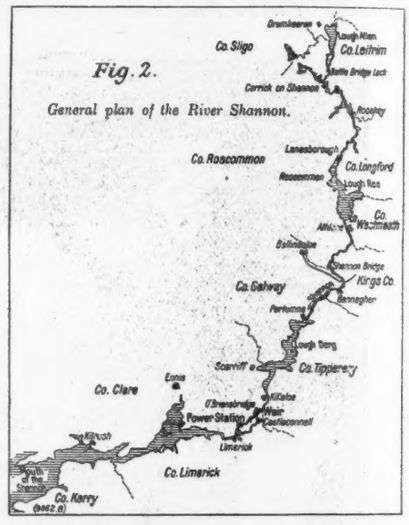


Fig. 1. — Longitudinal profile of the River Shannon.



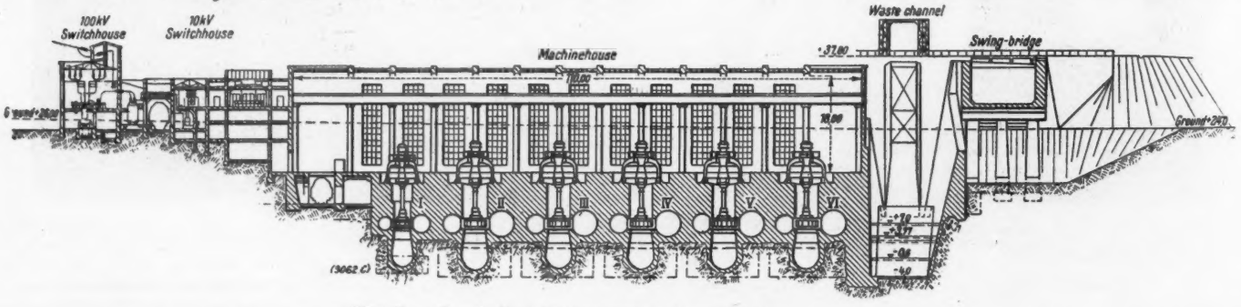


Fig. 3. — Longitudinal Section through the Power station

* "The Electrification of the Irish Free State: The Shannon Scheme. Siemens-Schuckert. The Stationery Office Dublin. [10s. 6d. net.]

† "The Electrification of the Irish Free State: The Shannon Scheme. Report of the experts appointed by the Government." The Stationery Office, Dublin. [4s.]

* For convenience of reference to the original, the figures quoted are expressed in the same units as are used in the text of the report.

In both stages of development the service water will be taken from O'Briensbridge, a point a little below the outlet from Lough Derg, where the river will be dammed by a weir bringing its water level up to that of the lake, and will pass thence along a head race about 10 km. long, to be constructed to deliver it in a single step at the power station, some 5 km. north of Limerick. A tail race, 1½ km. long, will conduct the water after use into the Shannon, together with the tributaries of the river between the lake and weir, for the accommodation of which side canals and, where necessary, syphons beneath the head race will be provided. These waters, with the overflow from the weir, are estimated to provide for the fisheries in the river without substantial injury, though an allowance for compensation is provided.

Provision for shipping is made by deepening parts of the Shannon bed and other works, and ultimately by constructing a ship lift.

The difference between head and tail water levels leaves in each stage of development an average useful head of about 30 metres and a minimum of about 27 metres, with which the necessary maximum quantity of service water required for generating the full power at low water is stated to be 246 and 542 cb.m./sec. for the respective stages of development. In the absence of drawings it is impossible usefully to follow the report into its description of the many consequential works that the above development will entail, but what has been said will be sufficient to indicate that they will be considerable. They include revision of the weir and lock arrangements at various points, and the provision of a number of bridges, &c. The damming of the river at O'Briensbridge and the eventual raising of the levels of the lakes will involve embanking the river for considerable distances, and in the endeavour to avoid flooding of the adjacent territory a system of catch trenches and pumps has to be provided, which the report claims will reduce the area of land exposed to flooding. In the full development these provisions alone involve 230 km. of embankments, 35 pumping stations and 40 syphons, and the suggestion is made that they may be made part of a still more extensive drainage programme. The extent of the main works may be illustrated by the fact that the construction of the head race will involve the excavation of some 5,000,000 cb.m. of earth, and of the tail race and power-station foundations nearly another 1,000,000 cb.m., in addition to a quantity of rock excavation so great that a liquid-air plant is to be installed for making liquid-air cartridges for the necessary blasting of rock on these works, in the river bed, and elsewhere. The best impression of the relative importance of the constructional works in the entire scheme will, however, be obtained from the figures of cost quoted later. Methods of calculation are given in the report.

The general arrangement of the power station is shown in section in Fig. 3, and in cross-section in Fig. 4 with indications of the water levels at various epochs. Its main divisions are a sluice house, a machine house, and switch houses. In the sluice house the water passes through a screen 92·3 metres long, provided with a mechanical cleaner, and is conducted to each turbine by a pressure pipe line 33 metres long and 6·0 or 4·5 m., diameter, according to the size of the turbine. The sluice house is divided into as many chambers as there are pressure pipes, each fitted with an electrically-operated sluice, the driving motor of which can be controlled from the power-house. The turbines are of the Francis type, with vertical shafts coupled direct to the generator shafts, and with spiral water inlets. Each is controlled automatically by an oil-pressure regulator, with the air vessels of the pumps that put the oil under pressure connected with each other by a common oil pipe, so as to act as reserve for each other. The efficiency of the turbines is calculated to vary from 84 to 87·5 per cent., according to the head for the time being. The partial development will provide two turbines each of 30,000-h.p. and one of 15,000-h.p., and the full development a further three of 30,000-h.p. each.

References must be made to the original for details of the electrical plant, both in the power station and at sub-stations, of the distribution system, and of methods of calculation. The generators are closed-type vertical machines, generating current at 10,500 volts, with a power factor of 0·7, and exciters for 220 volts; two machines in the partial scheme are of 30,000 kv.-a. output at 150 r.p.m., and one of 15,000 kv.-a. at 188 r.p.m., with three more of 30,000 kv.-a. in the full scheme. The line voltage is reckoned at 10,000. The generators are air-cooled, the heated air being used in winter for warming the station. The transformer plant in the station will consist in the partial development scheme of two 30,000 kv.-a., 10,500/110,000 volts and one 15,000 kv.-a., 10,500/38,500 volts transformers, and in the full development will have in addition two 30,000 kv.-a. one transforming to 110,000 volts, one to 38,500 volts and one 15,000 kv.-a. to 38,500 volts. Among the constructional details of the electrical plant attention may be called to the provisions for temperature control, the more so as the specification allows for a maximum rise of 100 deg. C. to 110 deg. C. in the slots of the generators. Quartz resistance thermometers, recording in the control room, are provided at the air inlets and outlets of the generators and in the stator shells, and copper-constantan thermocouples are inlaid in the iron of the stator on assembling. Resistance thermometers are also provided on the footstep and journal bearings to indicate and record the temperature of the lubricating oil. Each transformer has a resistance thermometer built in the oil tank. Automatic alarms are provided to indicate excessive heating in transformers, earthed choking coils, &c. and are connected electrically with a central alarm plant. The report gives particulars of the switch plant, and of the calculations determining the short-circuit currents and the choice of switches for the various circuits.

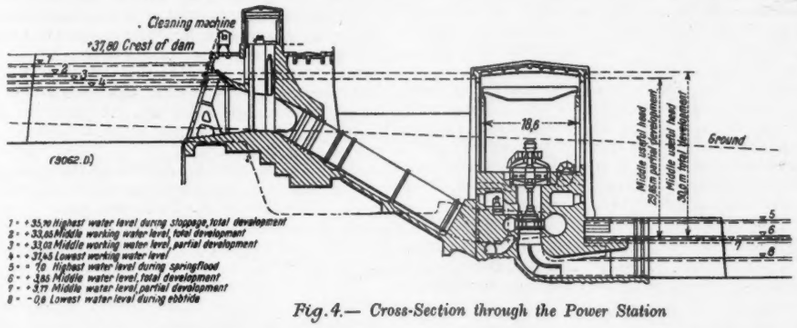

Cleaning machine
+37,80 Crest of dam
(9062.0)
18,6
Ground
Middle useful head 29,8m. partial development
Middle useful head 30,2m. final development
1 - +35,70 Highest water level during stoppage, total development
2 - +33,65 Middle working water level, total development
3 - +33,03 Middle working water level, partial development
4 - +27,43 Lowest working water level
5 - +10 Highest water level during springflood
6 - +3,85 Middle water level, total development
7 - +3,77 Middle water level, partial development
8 - -0,8 Lowest water level during ebbtide

Fig. 4.— Cross-Section through the Power Station

(To be continued.)

SCOTTISH MEETING OF THE INSTITUTE OF METALS.—The annual autumn meeting of the Institute of Metals will take place in Glasgow from September 1 till September 4, 1925. The Reception Committee will be presided over by the Right Hon. the Lord Weir of Eastwood, P.C., LL.D. Sir John Dewrance, K.B.E., Vice-President of the Institution, will deliver the fourth annual autumn lecture on the evening of September 1. During the period of the proceedings technical papers on subjects of interest will be read and discussed and visits to the leading engineering works in the district undertaken. For the convenience of applicants for membership of the Institute of Metals who are desirous of being elected in time to participate in the Scottish meeting a special ballot is being arranged, in connection with which membership application forms should be received by the Secretary, Mr. G. Shaw Scott, at 36, Victoria Street, London, S.W. 1, before June 30.

THE INSTITUTE OF TRANSPORT CONGRESS.

(Concluded from page 646.)

Two papers were taken during the session on Friday, May 15, the first being "Arterial Roads in Relation to Town Planning," by Mr. A. E. Brookes, the President being in the chair; and the second "Modern Dock Equipment," by Mr. H. J. Deane, Sir Joseph Broodbank taking the chair.

We summarise these two papers herewith:—

ARTERIAL ROADS IN RELATION TO TOWN PLANNING.

The growing importance of the roads is proved by the enormous increase in the volume and weight of traffic using them, due to the development of the mechanically-propelled vehicle. The increase has been very great since the end of the war, and the traffic may be assumed to be in weight five times greater than in 1914, about 95 per cent. being mechanically propelled, as against 45 per cent. in 1914. This great increase makes it essential to improve the roads in every possible way, and to construct new roads whenever necessary. The object of the paper is to suggest and encourage a broader outlook on the part of the highway authorities, and a more national view on the part of town planning authorities, in the lay-out of arterial roads when preparing town-planning schemes. The majority of the existing arterial roads are "main" roads, for the maintenance and improvement of which the County Councils are either directly or indirectly responsible. The authorities responsible for the remainder are the rural and urban and borough councils.

Much work on the arterial roads has already been done, and many new arterial and by-pass roads have been constructed, but the work done represents only a very small percentage of the whole. In this work the highway authorities are handicapped, as they have no statutory power to acquire land by compulsory purchase, except in certain limited instances. The possibility of action thus depends on arrangements being arrived at with owners and tenants, it is not possible except by agreement to sterilise land to provide for future developments, and the County Councils have no power to lay down building lines. Under the Roads Act of 1920, the Ministry of Transport have scheduled the more important arterial roads of the country as Class I. or Class II., Class I. being trunk roads connecting large towns, and Class II. secondary roads, connecting smaller towns. The usual practice of the Ministry is to adjudicate on schemes submitted by county or other local authorities, rather than to take the initiative, and they have no extra powers for land acquisition, except in the case of unemployment schemes. Under various Acts, any borough, urban or rural district council are empowered to prepare town-planning schemes. Joint town planning committees may be formed, and if the population of any borough or urban district exceeded 20,000 in 1923, the council must prepare a scheme within six years, failing which the Ministry may themselves act, or empower the County Council to do so. Under the Town Planning Acts, a County Council is not itself a town planning authority.

The main object of a joint committee is to agree upon and lay down lines of arterial roads, which will co-ordinate with those of the constituent areas, with due regard to lines of communication outside the area of the joint authorities. The author suggests that the County Council, who are at present only advisory, should be the town planning authority, so far as relates to the town planning of existing roads, and the lay-out of new arterial roads. The County Council could then convene joint conferences on lines best calculated to facilitate the passage of traffic, especially through traffic, and an agreed framework could then be incorporated in the individual schemes of the constituent authorities. The power to sterilise land would be of immense value to highway authorities, and action in this direction should not be delayed. There should only be one unit of rating in the country, the County Council being the sole highway authority. The burden of rates for highway purposes, other than main roads, varies very considerably. One district may have a low rateable value and a large mileage

of costly roads, while an adjacent district may have just the opposite. This is undesirable in the interests both of the ratepayer and of transport.

The final decision as to the width of existing main roads in town planning should rest with the County Council. The general tendency is to plan all arterial roads 100 ft. wide or over. This is unnecessary in some cases, and tends to prevent schemes being carried into execution. Except in exceptional cases, 100 ft. may be regarded as the maximum, and a single carriageway of 40 ft. is usually all that is required for arterial trunk roads carrying dense traffic. Generally, an overall width of 60 ft. and a carriageway of 30 ft., is sufficient for all requirements. Tramways should not, in future, be authorised to be constructed in the carriageway of any road, unless under exceptional circumstances. A single wide carriageway is preferable to duplicate tracks, a single carriageway of 30 ft. affording better facilities than two tracks of 18 ft. to 20 ft. each. Junctions and cross roads should be reduced to the minimum. The Ministry of Transport's contributions are practically confined to each financial year's revenue. It might be advisable that Parliament should agree to stabilise the revenue from the taxation of vehicles, or a sum equivalent to it, for a period of, say, 10 to 15 years.

Modern Dock Equipment.

The equipment of a modern dock may broadly be divided into that from which revenue is directly earned, such as from cargo-handling appliances; and such equipment as dock gates, generating plant, capstans, and the like. In both categories many improvements have taken place in recent years, but space and time will only permit of dealing with the more important from a revenue-earning point of view. For the same reasons, reference cannot be made to such items as special dock buildings, and such floating equipment as tugs, dredgers, &c.

For many years there has been considerable controversy as to the relative merits of hydraulic and electric power as applied to dock equipment, and at present no decisive judgment can be pronounced. The general tendency is to adopt electricity throughout in new constructions, but to maintain existing hydraulic plant until it is worn out, when it may be scrapped in favour of electric equipment.

Capstans.—Hydraulic capstans do not call for special reference. As regards electric capstans, considerable trouble was experienced in early days due to the failure of insulation on account of moisture condensation. This difficulty has now been overcome by improved insulation. Slipping clutches between the motor and capstan drum sometimes give trouble, but this may be overcome in the larger sizes by the use of squirrel cage motors, which do not require a slipping clutch. Capstans are more economical than either horses or locomotives for handling railway wagons, the type in which the wire rope is permanently attached to a free barrel being the most economical as regards the life of the rope and drum. A comparatively modern type of capstan possessing a number of good points has the driving machinery operated by oil transmission from an electric motor. The initial cost is, however, high.

Hydraulic Power Pumps.—The introduction of the multi-stage high-speed turbine pump has provided a substitute to the slow-speed direct-acting reciprocating pump. The high-speed pump can be driven either by electric motor or steam turbines. They have much smaller foundations and only occupy about one-third the space of the older pump. They have also a number of other advantages, but their mechanical efficiency has not yet reached that of the best of the older designs. In the case of impounding pumps, the electrically-driven centrifugal type has entirely superseded all others.

Heavy Lift Cranes.—At one time special lifting appliances were erected at fixed points on the quayside, either in the form of sheer-legs or steam cranes with revolving jibs. This involved bringing the vessel under the tackle, and the floating derrick has proved of great value on this account. Unfortunately, such classes of equipment cannot be looked upon as a direct-paying investment, as they will rarely be called upon for their maximum lifts. The class of trade and size of vessels frequenting a port generally fix the capacity of floating derricks. Ports obviously vary in their requirements, but certain of them are undoubtedly ill-equipped in this direction. It may be mentioned that on the Continent low-powered floating derricks have come into considerable favour, the Port of Rouen, for example, possessing 123 ranging up to 7½ tons capacity.

Quay Cranes.—For mixed cargoes the crane still remains the most useful amongst the various lifting appliances for general purposes. The modern quay crane is very efficient, but has certain outstanding defects. These are centred in the revolving motion imparted to the mass of material in the jib and parts revolving with it. Owing to the long outreach of modern cranes, they generally have to be luffed while being slewed, so that the jib and load may clear the ship's superstructure. Telpher and transporter systems only partially get over these objections, and have the drawback that the depositing area on the quay is much more limited than in the case of the crane. Several luffing cranes possess many advantages for this class of work. It is obviously desirable to arrange the crane as near to the quay edge as possible, but the high freeboard of modern ships renders a wide list clearance necessary. In addition, many vessels are now fitted with overhanging bridges and decks, and it would be a great advantage if the bridges could be hoisted clear when coming into dock or alongside the quay. As regards other appliances for handling general merchandise, gravity runways require fairly accurate adjustment as to levels, and a very appreciable height for long runs, while power-driven runways are not subject to these limitations. The latter may be either fixed or portable, and can be combined to transport goods for considerable distances, but the speed of the conveyors throughout must be uniform.

Electric Battery Trucks.—These may be used in cases where gravity or power-driven conveyors are not suitable. In order to get full service it is usual to provide portable platforms on which the goods can be loaded prior to transport. Such trucks may be employed with advantage on the upper floors of warehouses when warranted by the area of the floors. Tractors of the electric battery type are sometimes used, but appear to be mainly confined to terminal railway stations. They can under certain conditions compete very successfully with capstans and shunting locomotives, and their flexibility enables them to go where no capstans exist.

Warehouse Gantry Cranes.—Where sufficient height is available, this type of crane adds to the value of the storage accommodation, as it reduces the necessity for large trucking ways. They are of two main classes, the travelling gantry, and the underhung jib type. The former have the disadvantage that it is very difficult to arrange for any travel beyond the walls of the warehouse. The important advantage attaching to the underhung jib type is that the jib can readily be arranged to reach out on one side of the quay and transfer its load to any position within the bay in which the crane operates, or for a width of half of each adjacent bay, or right through to a railway van or lorry on the other side of the warehouse.

Timber Discharging.—Very little progress has been made in modern equipment for handling timber ex-ship. It frequently happens that a berth occupied for over a week by a ship during discharge takes another three weeks to clear ready for the next ship. Two solutions have been suggested, either an ample supply of wagons on the keyside in association with ample space in the hinterland, or some form of continuous transporter doing away with track, rolling-stock, and their accompanying shunting operations.

Bulk Grain Handling.—Grain may arrive as principal or part cargo. In the former case the grain is best dealt with at the quay adjunct to the silos or granary, while the latter requires to be discharged where the general cargo is received. The bucket elevator offers the more rapid treatment for large consignments, its principal disadvantage being the necessity for feeding it by hand or mechanical plough. In addition the bucket elevator cannot clean up the bottom of the hold unaided. The floating pneumatic elevator offers great advantages for part cargoes, as the suction pipes may be threaded through any openings to extract the grain from all odd spaces.

Discharging Ore and Coal.—Grabs are an essential part of the equipment in this case. There are three general types, namely, single chain ring discharge, dumping, and double, treble or quadruple grabs. The principal advantage of the first type is that it can be used with any type of chain or hoisting appliance, but it must always be discharged from the same height. The second type overcomes this difficulty, but in this case the weight of the grab as well as its load has to be borne by the wagon. The third type gives absolute control by the operator over all movements, and this gives it a decided advantage over the others.

The discussion on this paper was opened by Mr. R. T. Smith, who, referring to the type of capstan having a steel rope fixed to the barrel, said that about 150 of these were in use on the Great Western Railway. They possessed the great advantage that they could be mastered by an unskilled labourer in a very short time, and in addition required only about half the amount of energy of the slipping rope type. In reference to the controversy concerning the relative merits of hydraulic and electric plant, the cost of maintenance of hydraulic plant was lower, but each system possessed particular advantages for certain classes of work. With regard to overhead cranes in warehouses, the gantry crane was probably the best type, but the underhung jib crane, which was cheaper, would possibly come into wider use. A platform truck could be employed with great advantage for railway warehouses.

Major Du-Platt-Taylor referred to the differences in the degree of equipment provided at different ports. The absence of effective equipment in some ports involved the provision of the equivalent on the ship, and the cost of the latter would be reduced if all ports could be brought into line.

Mr. F. E. Wentworth-Sheilds said that at Southampton they did not replace hydraulic by electric cranes until the useful life of the latter was over; but that this did not apply in the case of pumping machinery, as the greatly increased economy of electric motor-driven turbine pumps justified the change over before the old steam plant would normally be renewed. As regards capstans, he thought them undesirable on quays to which the public had access. The use of 12 to 16-ton steam cranes which could be placed on any quay had been found very advantageous, the quays at Southampton being wide enough to permit of long lines of rails on the quay. He thought that a really efficient portable grain elevator was badly needed, those he had tried being unsatisfactory. They had found battery trucks very useful, and had installed 28 of these each having a capacity of 2 tons.

Mr. H. Hopperton expressed the opinion that the equipment of British ports was fully comparable with those of the Continent. The handling of timber offered a wide field for improvement. He would like to know whether the battery truck had been applied in this case. He had had a wide experience with capstans of the fixed rope type, and considered they were the best appliance for moving wagons. With regard to cranes he had had experience at Ardrossan of steam, hydraulic, and electric cranes, and in general had found the relative costs to be as 4, 2 and 1, in the order named. The electric luffing crane appeared to be the most valuable of all the types available.

Mr. Isserlis said that the difference between British and Continental ports appeared to lie in the labour conditions rather than the equipment. He agreed with Mr. Hopperton that the handling of timber was a very important question, and suggested that the Institution might perhaps give a lead in the direction of the best solution.

Mr. A. G. Gardner referred to the fact that at Immingham they had a modern system of hydraulic cranes, while at Grimsby the system was very old. The authorities were considering the substitution of the hydraulic by electric cranes at the latter port, but at Immingham the hydraulic system

had been found entirely satisfactory, and any extensions would probably be in the same direction.

Mr. B. Cunningham mentioned that he had had unusual opportunities of studying the methods adopted for unloading cargo in various ports, and he was struck by the diversity of prevailing practice. A critical comparison of the various methods would be valuable, as while giving due weight to local conditions, it might be possible to evolve a system which would be better than any other for any particular port. He thought that the conveyor system had decided advantages over that of the swinging boom. He referred to the special overhead runway system in use at one of the London docks, in which tracks went over the ship's hatchway, and a portion could be detached with its trolley and lowered into the hold. On return to the line, a system of switches would enable the trolley to be delivered to any part of the shed.

Sir Joseph Broodbank, speaking from the chair, referred to the conditions of the timber trade. It should not be forgotten that this was a seasonal one, so that extended quay accommodation would be very expensive. He felt that the real solution lay in better loading at the port of shipment.

In replying to the discussion, Mr. Deane quoted his own experience in the use of hydraulic power, and referred to the great difficulties associated with the timber trade. He also referred to the remarks made in connection with port as compared with ship equipment, and the labour difficulty mentioned by Mr. Isserlis.

On the completion of the papers by Messrs. Brookes and Deane, the members and delegates assembled for the conclusion of the formal business of the congress. The chair was taken at this meeting by the President, Sir Lynden Macassey, K.C.M.G., and Mr. H. Mattinson moved a resolution "That the Council be invited to appoint a special committee to consider what steps can be successfully taken to organise the various forms of transport using the highways of the country, and to co-ordinate such interests with those of the railways." The resolution was seconded by Sir J. Broodbank, and carried unanimously, and was followed by votes of thanks to all who had contributed to the success of the congress.

Following this meeting visits were arranged for the Friday afternoon session to the London docks, or to the Pakenham Street garage of Messrs. Carter, Paterson and Co., Limited, as an alternative. The proceedings finally concluded with a visit to Southend on the Saturday morning.

DUPLEX TOPPING, BOSSING AND BORING MACHINE.

THE duplex machine which we illustrate in Figs. 1 to 28, on page 672, and Plate XLV, which accompanies our issue of this week, has been designed by Lieut.-Colonel H. V. Kitson for the rapid machining of railway wheel centres. It is being manufactured by Messrs. Campbells and Hunter, Limited, of Leeds, and the first completed machine has been installed in the works of the Leeds Wheel and Axle Co., Limited, of which firm Lieut.-Colonel Kitson is a director. The machine is fully protected by patents.

All the operations on railway wheel centres can be performed at one setting; the various tools for turning the outside and facing both sides of the rim, facing both sides of the boss and boring out the latter all operating at the same time. Immediately on the completion of the facing operations, the radius and grooving tools can be brought into action, and the whole of the work can be completed during the longest operation, which consists in boring out the boss. A very high output is thus obtainable. A special hydraulic crane is incorporated in the machine for the purpose of lifting the work on or off the table, and the chucks, driver and clamps are arranged so that there are no loose parts to be removed and replaced when changing the wheels. In cases where hydraulic power is not readily available, the crane can be arranged for electric or hand-operation as required.

As will be seen from Figs. 1 and 2, the machine is of the vertical mill type, two independant machines being incorporated in one bed. The controls are all brought to the front of the machine within easy reach of the operator. Owing to the irregular nature of the forged wheel centres before machining, an independent jawed chuck is employed for centering the work, and between each jaw of the chuck there is a combined clamp and driver, the clamp clipping over the spokes of the wheel and being tightened down by the same spanner which serves to operate the chuck jaws. The chuck jaws and clamps can be clearly seen in Fig. 1, and it will be observed that the whole of the wheel centering and clamping can be performed by the one spanner from the most convenient position.

As will be seen from Figs. 1 and 3, there are three vertical slides carrying tool heads, and in addition tools are carried in the boring bar; and in tool holders located inside the table column. The tools are thus located in five groups, which we will deal with in order.

The saddle on the left-hand slide in Fig. 1 or 3 carries a roughing and finishing tool for the outside of the rim. A vertical downward power traverse is provided; and after the lower, or roughing tool, leaves the lower edge of the rim, the traverse is automatically tripped, and cannot again be brought into action until the lower tool bar has been withdrawn sufficiently for the tool to clear the table. The tool is shown in the latter position in Fig. 3. A vertical hand traverse is also provided and is operated by the side wheel, shown at the base of the slide in Fig. 3. The two tool bars are provided with independant horizontal hand-traverses operated by the two hand wheels at the left-hand end of the tool bars. The weight of the saddle is taken on a hydraulic ram plunger, but the machine can be provided with a counterweight, or other balance system, when the latter would be more convenient.

The right-hand slide carries two independent saddles, which carry the upper and lower facing tools. On the completion of the facing operation the grooves are formed. Figs. 1 and 3 show the tools in position. Horizontal power traverse is provided for both tool bars, and is brought into operation by means of the clutch levers on the right-hand end of the saddles, the two small levers projecting beyond the saddles on the extreme right being for the purpose of tripping the clutches. The motion is also provided with adjustable automatic trips. Horizontal hand traverse is provided in addition, the star wheels for this purpose being clearly seen in Fig. 1, and the handwheels for the vertical hand traverse for the two heads can be clearly seen in the same figure.

The centre saddle carries the tool heads for the upper boss-facing tool on the left, and the upper boss-radiusing tool on the right. The facing tool head is provided with both power and hand-operated horizontal traverse, and the radiusing tool with horizontal hand traverse only. The hand wheels for the hand traverse can be seen on the tool boxes. The saddle is provided with power lift for rapidly clearing the work when the wheel centres are changed, and a vertical hand traverse is fitted to the saddle in addition. This is operated by the smaller of the two concentric hand wheels, which can be seen at the level of the crane arm in Fig. 2.

The boring bar carries two roughing and two finishing tools, the latter being the upper pair shown in Fig. 3. The main spindle, which carries the boring bar, is provided with a downward power feed for cutting, and in addition, has a quick up or down power feed to clear the bar rapidly when changing the work. A hand traverse to the bar is also provided, operated by the larger of the two concentric hand wheels already referred to. All the movements are interlocked and fitted with trip gear, so that only one can be in operation at any given time. In passing, it may be mentioned that the whole of the machine is rendered fool-proof in the same way throughout.

The lower radiusing tool for the underside of the boss, which is on the left-hand side, is hand-operated only in both the vertical and horizontal directions, the two hand wheels for this purpose being mounted at the top of the operating column, seen in Fig. 1 in front of, and to the left of the machine. The tool for facing the underside of the boss is operated in the same way from the operating column, to the right of the machine, but in this case a horizontal power feed is provided, in addition to the vertical and horizontal hand feeds given by the hand wheels on the column. The power feed is brought into operation by means of a pawl and rachet device carried on the plunger box, which can be seen behind the right-hand control column in Fig. 1.

Before going into detail, we may say that the machine shown in the illustrations is belt-driven, a friction clutch being provided on the belt pulley, but motor drive can be fitted if desired. The clutch-operating lever can be seen projecting beyond the right-hand control column in Fig. 2. A separate suds pump is provided for each machine, which pumps the suds from a sump below floor level into a tank fixed on the side of the machine, from which it is fed to the various tools by gravity. The sump also serves as a reservoir for the scarf, and contains a large filter which prevents the latter collecting in the sump proper.

Turning now to the construction of the machine in more detail, the main table and spindle drive is shown in Fig. 4. A worm is keyed to the belt pulley shaft, and this gears with a worm wheel keyed to the top of a vertical shaft inside the machine column. This shaft serves to transmit the drive to the spindle bar and to the table. The latter, which is carried on a large diameter cone seating, has teeth cut round its periphery, and these engage directly with the spur pinion mounted at the lower end of the vertical shaft. The main spindle drive is given by the train of three wheels seen in the lower box in Fig. 4, the engagement with the vertical shaft being through a hand-operated dog clutch as shown. A second smaller diameter vertical shaft, for actuating the boring bar feed motion seen in the figure to the right of the main shaft, is driven at the lower end through the pair of spur wheels shown above the main wheel group in the lower box, and at the top drives a skew gear, the second wheel of which runs free on a horizontal shaft.

The spindle and feed quick-traverse motions are taken from this horizontal shaft, which is shown in detail in Fig. 5. When the dog clutch shown on the right is moved to the right, the horizontal shaft is driven by a train of wheels outside the box direct from the pulley shaft, and by moving the second clutch, shown on the left in the drawing, either to right or left the short vertical shaft carrying the horizontal bevel is rotated in one direction or the other. Returning to Fig. 4, it will be observed that a spur wheel at the lower end of the last shaft referred to gears with a long nut through which the spindle passes, and as the latter is threaded it is raised or lowered by this means. To engage the slow feed for the boring bar, the right-hand clutch in Fig. 5 is moved to the left, and the shaft is then driven through the skew gearing from the main vertical shaft, the motion to the spindle nut being through the appropriate bevel wheel pair as before.

The traverses for the various tool heads are as follows. Referring to Fig. 3, it will be seen that the spur wheel formed by the teeth cut on the periphery of the table engages with two pinions, keyed to the lower end of two vertical shafts which can be seen on either side of the wheel centre. These shafts supply the power for the various feed mechanisms on all three saddles. Dealing with the left hand saddle first, the arrangement is shown on Figs. 14 and 15, from which is will be seen that the upper end of the left-hand vertical spindle carries a bevel wheel, and this engages with a corresponding wheel on a short cross shaft. From this shaft the drive is taken through skew reduction gearing to a wheel which normally runs freely on the top of the saddle screw, to which it may be locked when required through the medium of a dog clutch. Fig. 14 also shows the vertical hand traversing mechanism engaging with the lower end of the saddle screw. The arrangement of the hand-operated horizontal traverses for the tool bars will be clear from Figs. 3 or 14. The handwheels rotate screwed spindles through the skew gears shown, and a nut projecting from the tool bar engages with these spindles.

The right hand vertical shaft, driven as described from the table, actuates the lifting gear for the centre saddle, the power traverse for the upper boss facing tool carried in the left hand tool-box on this saddle, and the horizontal power traverses for the two tool heads carried on the left hand saddle. The details of this mechanism are shown in Figs. 6 to 13. Dealing with the centre saddle first, the mechanism for lifting this will be clear from Figs. 10 and 12. From Fig. 10 it will be seen that a worm wheel at the top of the shaft which transmits the drive from the table engages with two worms, the rear one of which is keyed to a cross shaft carrying a bevel on one end, and geared to a vertical screwed spindle engaging with a nut on the saddle at the other. The nut can be clearly seen in Fig. 12. The bevel engages with a cross shaft carrying the wheel for the vertical hand traverse of the saddle, this being the outer of the two large wheels shown in Fig. 10. The clutch for engaging the power traverse can be seen to the left of the gear-box in the same figure.

Turning next to the traverse for the left-hand tool head carried on the centre saddle, it will be observed from Fig. 12 that the vertical shaft transmitting the drive from the table carries a wheel engaging with a second on a short vertical shaft in the tool head, and that this in turn actuates a screwed spindle, through the medium of a clutch, to give the horizontal power feed to the tool. The hand feed arrangement, operating through bevels on the other end of the screwed spindle will be clear from the same figure.

The horizontal power traverses for the two tool heads, on the right-hand saddle may now be taken. Referring again to Fig. 10, these power traverses are actuated by the front horizontal shaft, the skew gears shown at the right-hand end being at the top of the vertical shaft seen on the extreme right in Fig. 3. This shaft drives two skew gears normally running free on the upper and lower saddle spindles respectively, and the latter are engaged or disengaged with the appropriate spur wheel

by means of the clutch and trip mechanism shown in Figs. 12 and 13. The horizontal hand traverses are given by hand wheels actuating the saddle spindles through skew gearing, and the tool bars are traversed by the rotation of the spindles by means of a projecting nut, as in the case of the left-hand tool bars.

Before leaving this part of the mechanism, reference may be made to the hand traverse of the main spindle. It will be remembered that the inner of the two large hand wheels, shown in Fig. 10, is for this purpose, the bevel on the inner end of the sleeve carrying this wheel engaging with a similar bevel on the inclined shaft, which can be seen in Fig. 1. The drive is taken from the upper end of this shaft through a suitable wheel train to the main spindle nut.

As already mentioned, the tools for operating on the underside of the boss are within the table column, and the controls are carried to the two control columns, which can be seen in Fig. 1, on each side of the machine. The arrangement of the various feed mechanisms is shown in Figs. 16 to 28. Dealing with the left-hand column first, which carries the mechanism for controlling the radiusing tool for the underside of the boss, it will be observed from Fig. 16 that the tool-holder is carried in a block, which is free to slide between suitable guides in a radial direction to impart the horizontal motion to the tool. A short rack is attached to this block, and engaging with this is a racking pinion, which is mounted at the upper end of the vertical spindle seen to the right in Fig. 16. A worm wheel at the base of this spindle engages with a worm on the inner end of the horizontal shaft, which can be seen on the left in Fig. 24, and the shaft carries a bevel wheel at its outer end, which is operated by the upper of the two hand wheels on the column, as seen in Fig. 17. The vertical motion is imparted to the tool-holder by a second train, actuated by the lower of the two hand wheels on the control column. It will be observed in Fig. 17 that, by means of a second pair of bevels, the rotation of this wheel is imparted to the upper of the two horizontal shafts. This shaft is seen in place in Fig. 25, from which it will be seen that its inner end carries a worm, which engages with a worm wheel running loose on, and concentric with, the vertical spindle seen in Fig. 16. This free wheel engages with a second worm wheel forming part of a nut running on the screwed end of the tool-holder, so that its rotation causes the latter to rise or fall. The horizontal motion of the tool-holder will tend to throw the final pair of worm wheels out of mesh, but the movement is actually too small to affect appreciably the engagement of the wheels.

The operation of the right-hand tool-holder, which carries the lower boss-facing tool, is modified by the fact that the horizontal movement of the tool-head has to be much greater, and is in addition provided with a power traverse. We will deal with the vertical motion of the tool-head first, which is hand-operated from the lower of the two hand wheels on the right-hand operating column. Referring to Fig. 19, it will be seen that this hand wheel is mounted on a sleeve which carries a bevel wheel at its lower end, and this wheel engages with a second bevel carried on the outer end of the horizontal spindle seen on the right in Fig. 25. A worm is mounted on the inner end of this shaft, which engages with a worm wheel attached to the sleeve seen encasing the vertical spindle on the right in Fig. 17. The upper portion of this sleeve is screwed, and engages with a nut which is mounted in the saddle. The latter can be clearly seen in section in Fig. 24, and its general shape can be gathered from Figs. 27 and 28. It can also be seen in place in Fig. 25, from which figure it will be seen that it partly embraces the central column.

Turning now to the horizontal feed for the tool-holder, it will be observed from Figs. 25 and 27 that the saddle to which we have referred carries a cross-saddle working in horizontal dovetail grooves. For purposes of description we will refer to this cross-saddle as the slide. It can be seen in place in Fig. 25, resembling somewhat in shape a curved lever, the form of the back being such as to give maximum cross-section to the arm while permitting of the necessary travel without fouling the inside of the table column in its outer position. The method of imparting motion to the slide will be clearest if reference is made to Fig. 17. It will be observed that the right-hand vertical spindle in this figure carries a racking pinion at its upper end. The rack with which this engages is attached to the slide, and is shown in cross-section. The racking pinion is actuated by the lower of the two worm wheels on the vertical spindle, and this wheel engages with a worm on the end of the horizontal shaft seen in Fig. 24. The hand operation by the upper of the two hand wheels on the control column will now be clear on reference to Fig. 19; and, referring back to Fig. 24, it will be seen that a second bevel, mounted on the end of a short horizontal shaft, engages with the large horizontal bevel wheel keyed to the hand-wheel spindle. This second bevel is operated by the mechanical-traverse motion as follows: A cam having two crests, which is shown dotted in Fig. 25, is attached to the machine table and operates the spring-loaded plunger which is seen terminating in a cam roller in the same figure. The roller and plunger-rod can also be seen in Fig. 17, from which it will be seen that its motion imparts a semi-rotary movement to a cross-shaft mounted below it, through the medium of a lever of which the head engages with a slot in the plunger. The cross-shaft carries the ratchet mechanism, shown in Figs. 18 and 19, and this operates the ratchet-wheel shown mounted on the short bevel shaft in Fig. 24. The extension to the ratchet feed mechanism, shown passing under the table in Fig. 17, forms part of the tripping arrangement for the lower boss facing tool. It is connected to the spring loaded column, shown in Fig. 27, through the medium of the short shaft shown in Fig. 23, and the method of operation is briefly as follows: the adjustable stop, shown in the dovetail groove on the slide in Fig. 27, rides on the top of a fixture keyed to the vertical rod, and rotates the latter against the pressure of a spring. When the tool has completed its traverse the spring is released, and in unwinding closes the path of the ratchet pawl by means of a projection on the hand lever which is interposed between the pawl and the ratchet.

In concluding our description of this interesting machine, we may refer to the manner in which the boring-bar tools are arranged to register with the clearance slots provided in the lower guide bush, as this arrangement is typical of the careful manner in which all the details have been worked out. Two vertical featherways are cut in opposite sides of the nose of the boring bar, and terminate just before the end, which is therefore of unbroken circular section. The bush is provided with spring-loaded feathers, which engage with the featherways and locate the bush with respect to the bar in the correct position for passing the tools through the slots provided. The descending bar first pushes the feathers into their recesses, and after the unbroken section of the bar has passed, the feathers spring back and engage with the featherways, causing the bush to rotate with the bar with the clearance slots for the tools in their correct position. In the first design the position of the feathers and the featherways was reversed, as shown in Figs. 17 and 25, but the alternative arrangement described has been found preferable.

The illustrations show the machine operating on forged spoke wheel centres, but the machine deals with centres of the disc type equally well.

THE HASTINGS ELECTRIC POWER STATION.

ELECTRIC supply in the County Borough of Hastings dates back to 1882, from which time a supply of single-phase current at a frequency of 100 cycles has been available. The original works, situated in Earl-street, were, of course, enlarged from time to time as the demand increased, the most recent extension being made in 1922, when the capacity of the station was practically doubled by the installation of a Brush-Ljungström turbo-alternator with a capacity of 1,125 kw. Although it was then fully realised that the plant could not cope for long with the increasing demand for current, land for further extensions to the Earl-street station was not available, and the turbo set above referred to was put down merely as a temporary measure. The view of the Electricity Commissioners was that an entirely new station should be constructed to give a high-tension, three-phase supply at 50 cycles, not only for the existing load, but for the bulk supply of other authorities in the neighbourhood. This has now been done, and the new station was officially opened on Friday last, the 22nd instant.

After carefully considering the possibilities of a station erected on the coast where sea water could be used for the condensers, it was finally decided, for reasons which need not be discussed here, to erect the station on an inland site and to use cooling towers for the circulating water. The site selected was at Broomgrove, near Hastings, on the Ashford-Hastings branch of the Southern Railway, and in a valley running parallel with the direction of the prevailing winds, thus facilitating the working of the cooling towers. Advantage has been taken of the natural slope of the ground to place the towers in such a position that the circulating pumps and condensers are always flooded, and the site has the additional advantage that ample space is available for future extensions.

The lay-out of the station, which was designed and constructed under the supervision of Mr. Russell F. Ferguson, M.I.Mech.E., M.I.E.E., the Borough Electrical Engineer, is well shown in the transverse section and plan reproduced in Figs. 1 and 2, respectively, on page 667, while Fig. 3, on page 668, illustrates its external appearance. Structurally, the station is interesting in that the whole weight of the plant, with the exception of the turbo-generators and condensers, is carried on steel beams and stanchions, the latter being supported on concrete foundations taken down to a depth of 16 ft. below the ground level. Another interesting feature is the use for the roof and walls of Robertson's bitumen-asbestos-protected corrugated steel sheets manufactured by the Wolverhampton Corrugated Iron Co., Limited. This material is, of course, considerably cheaper than brickwork and concrete, while its life is longer than ordinary corrugated iron; it is also a better heat insulator than the latter material. As will be clear from Figs. 1 and 2, the station is divided into three main bays, that on the right being occupied by the bunkers, that at the centre by the boilers and that on the left by the generating plant. At one end of the boiler-room is a pump-room in which the feed pumps, a P & B evaporator and a Kestner degasser are located, while in the open, close to this, is a Paterson water-softening plant. The latter, however, is only used for treating the circulating water, the make-up feed being supplied by the evaporator. Messrs. Fairweather and Ranger carried out the supply and erection of the steelwork, the construction of the roads and the foundation work for the boilers and generating sets, as well as the construction of the reinforced-concrete pond for the cooling towers.

The capacity of the plant, as at present arranged, is 9,500 kw., including three Brush-Ljungström turbo-generators of 5,000 kw., 3,000 kw. and 1,500 kw. capacity. Space is, however, provided for the installation, in the future, of a set having a continuous overload rating of 7,000 kw. At the time of writing, only the 5,000 kw. and 3,000 kw. sets are actually installed, but the foundations and circulating pumps for the 1,500 kw. set are now ready. Actually this set will use the turbine of the 1,125 kw. single-phase set above referred to as having been installed comparatively recently in the Earl-street Station, two new three-phase generators being ready for fitting to this turbine. This will be done as soon as a part of the area has been changed over for the three-phase supply, so that some of the load can be carried by the new plant.

The turbo-generators, with their condensing plant and auxiliaries, were supplied by the Brush Electrical Engineering Company, Limited, Loughborough; Fig. 4, on page 668, illustrates the 5,000 kw. set, and also shows the 20-ton overhead traveller by Messrs. Herbert Morris, Limited, with which the engine room is equipped. Three-phase current is generated at 6,600 volts, and 50 cycles, the sets running at 3,000 r.p.m. and being capable of carrying an overload of 25 per cent. for two hours. Steam is supplied at a pressure of 250 lb. per square inch at the turbine stop valves and at a temperature of 650 deg. F., while the condensing plant is designed to give a vacuum of 28 in. of mercury with the barometer at 30 in. and with cooling water supplied at 75 deg. F. All the main bearings, including the governor and thrust-block bearings, are supplied with oil under pressure from a rotary pump of the valveless type, and, in addition, a separate steam-driven oil pump is provided to assist the rotary pump when starting. This auxiliary pump is started up automatically in the event of the oil pressure falling below a predetermined value, and it should also be mentioned that Crosby automatic oil regulators are fitted on each set. An automatic governor, which operates the governor valves through a pressure regulator, is provided and the governor can be controlled either by hand at the turbine or electrically from the switchboard. The turbine rotors are directly connected to the generator rotors by rigid couplings and the two generators of each set are connected in parallel at their respective panels on the extra-high tension switchboard, Merz-Price gear being provided for their protection.

The necessary cooling air for the 5,000 kw. set is provided by a centrifugal fan, driven by a 42 h.p. Brush squirrel-cage motor running at 970 r.p.m. and capable of supplying 20,000 cub. ft. of air per minute against a head of 7 in. of water. The air is drawn through an oil-type filter made by Messrs. Cleworth, Wheal and Co., Limited, the arrangement being similar to that illustrated in Fig. 5 on page 669, which however, shows the air ducts and filter of the 3,000 kw. set. The filters, we understand, are capable of removing 98 per cent. of the impurities present in the air and the system includes an alarm giving visual and audible warning in the event of a failure of the air supply. As usual with this type of plant, the turbo-generators are mounted directly on the condensers which are designed to carry the whole of the weight. The condenser for the 5,000 kw. set is designed to deal with 53,700 lb. of exhaust steam per hour and of maintaining a 28-in. vacuum with 5,650 gallons of cooling water per minute supplied at the temperature above mentioned. Air extraction is effected by Brush-Delas ejector plant capable of extracting 31·25 lb. of dry air per hour. The condensate is extracted by a Pulsometer centrifugal pump which can handle 90,000 lb. of water per hour, delivering against a total head of

THE BROOMGROVE POWER STATION OF THE BOROUGH OF HASTINGS.

MR. RUSSELL F. FERGUSON, M.I.MECH.E., M.I.E.E., BOROUGH ELECTRICAL ENGINEER.

Fig. 1

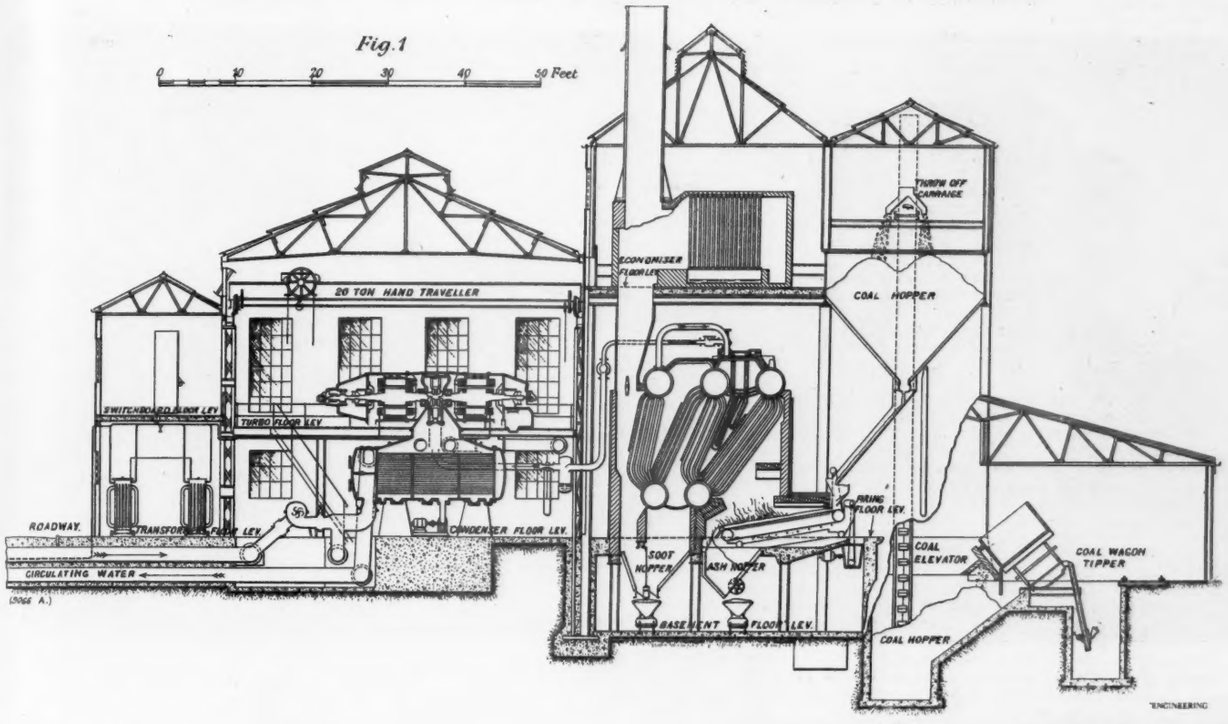
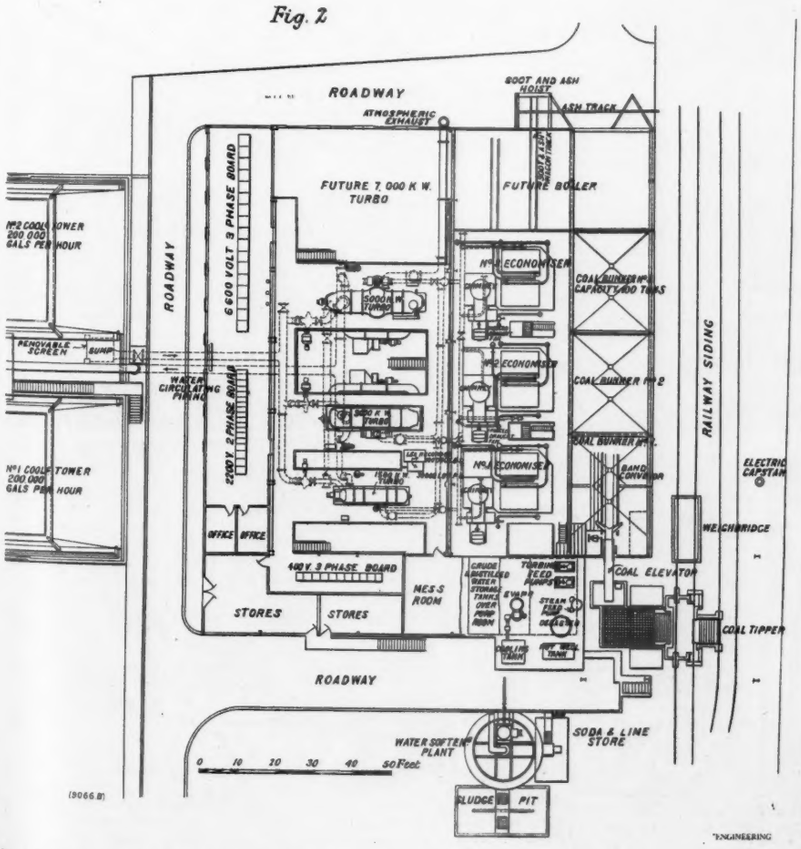


Fig. 2



57 ft.; it is driven by a 5½ h.p. squirrel-cage motor running at 1,410 r.p.m. A Drysdale centrifugal pump of the split-casing type supplies the circulating water, this pump, which is driven by a 92 h.p. slip-ring motor running at 960 r.p.m., being capable of delivering 5,650 gallons per minute against a total head of 38 ft. The condensing plant for the 3,000 kw. is of generally similar design, its capacity being 32,700 lb. of exhaust steam per hour with 3,450 gallons of cooling water per minute. The two cooling towers, which are of the natural-draught type, were supplied by The Premier Cooler and Engineering Company, Limited, and each is designed to deal with 200,000 gallons of water per hour, reducing its temperature from 90 deg. F. to 75 deg. F. with an air temperature of 60 deg. F. and a humidity of 75 per cent.

Steam is, at present, supplied by three Stirling boilers, fitted with integral superheaters and having Green's economisers mounted above them; space is, however, provided for a fourth unit, when required, as indicated on the plan, Fig. 2. A view of the interior of the boiler-house is given in Fig. 7, on page 669. The boilers work under induced draught, the guaranteed efficiency of the units being 84 per cent. Each boiler has a heating surface of 7,563 sq. ft., and its rated evaporative capacity is 30,000 lb. of water per hour at full load, although a 25 per cent. overload can be maintained continuously. The working pressure is 265 lb. per square inch, and the superheaters are capable of increasing the temperature of the steam by 269 deg. F., so that the total temperature of the steam at the boiler stop valves is 680 deg. F. Each boiler is equipped with a Babcock and Wilcox chain-grate stoker, designed for bituminous or semi-bituminous coal, and all the stokers are driven from a shaft in the basement, running along the whole length of the boiler-room. A 6-h.p. slip-ring motor is mounted at each end of this shaft, one acting as a stand-by. A Lea coal-meter is fitted to each stoker to give the coal consumption, and the steam production of the boilers is measured by Electroflo indicating, integrating and recording flow meters. Crosby automatic coil-type feed-water regulators are fitted on each boiler, and Cambridge distant-reading thermometers are provided for measuring the temperature of the superheated steam, flue gas and feed water.

The ashes and soot are collected in hoppers below the boilers, and are discharged at intervals into trucks running on rails in the basement, as is most clearly shown in Fig. 1, while two of these hoppers are also visible in Fig. 7. The trucks are pushed along by hand to one end, where they are raised by an electric hoist with a specially designed sling and conveyed along a runway for discharge into railway trucks on the adjacent siding. The economisers, as previously mentioned, are mounted above the boilers, and, as will be understood from Figs. 1 and 2, are each arranged in two groups. Each group consists of 128 tubes, 9 ft. in length, and the damper equipment provided enables the flue gases to be passed round the two groups of tubes in series or to be by-passed directly

THE BROOMGROVE POWER STATION OF THE BOROUGH OF HASTINGS.

MR. RUSSELL F. FERGUSON, M.I.MECH.E., M.I.E.E., BOROUGH ELECTRICAL ENGINEER.

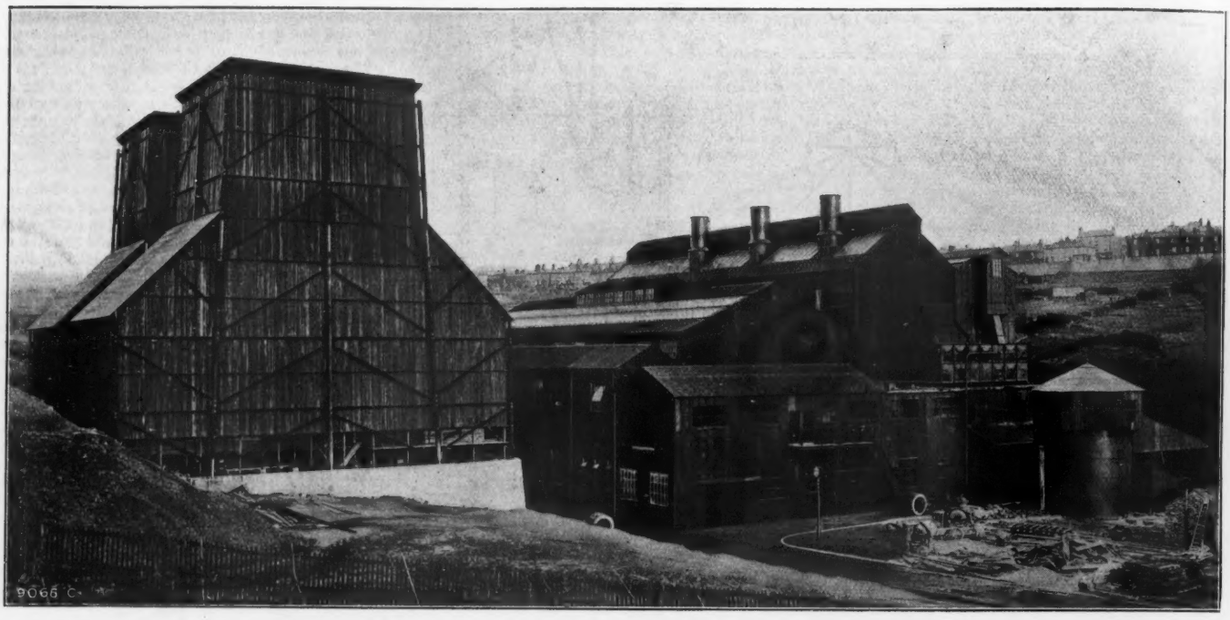


FIG. 3. POWER STATION BUILDINGS AND COOLING TOWERS.

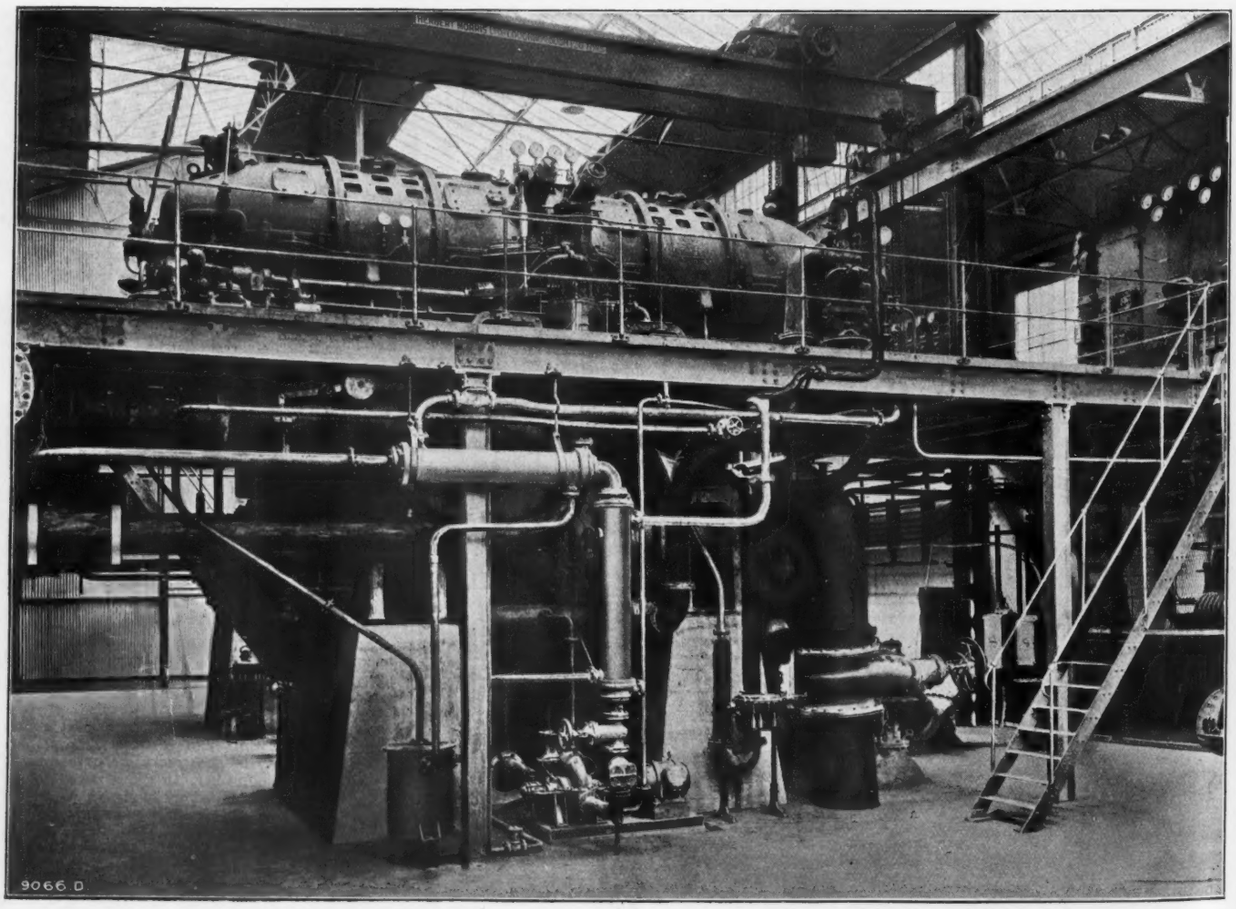


FIG. 4. 5,000-KW. BRUSH-LJUNGSTRÖM TURBO-GENERATOR AND CONDENSING PLANT.

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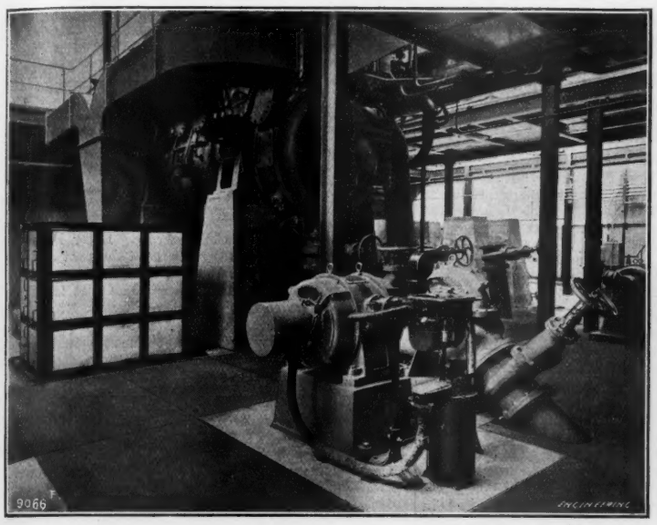


FIG. 5. AIR FILTER AND CONDENSING PLANT OF 3,000-KW. SET.

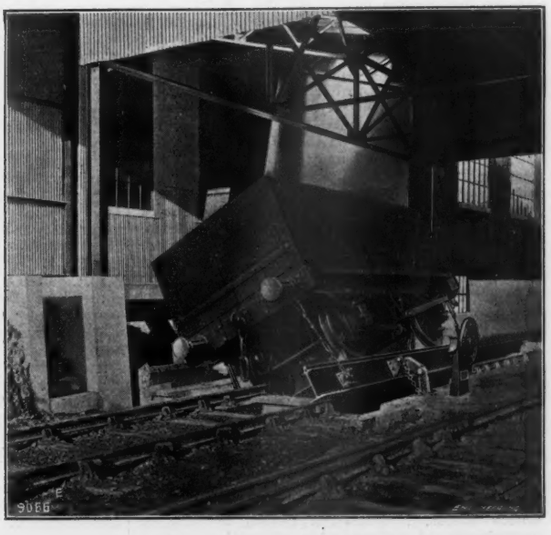


FIG. 6. COAL WAGON TIPPER.

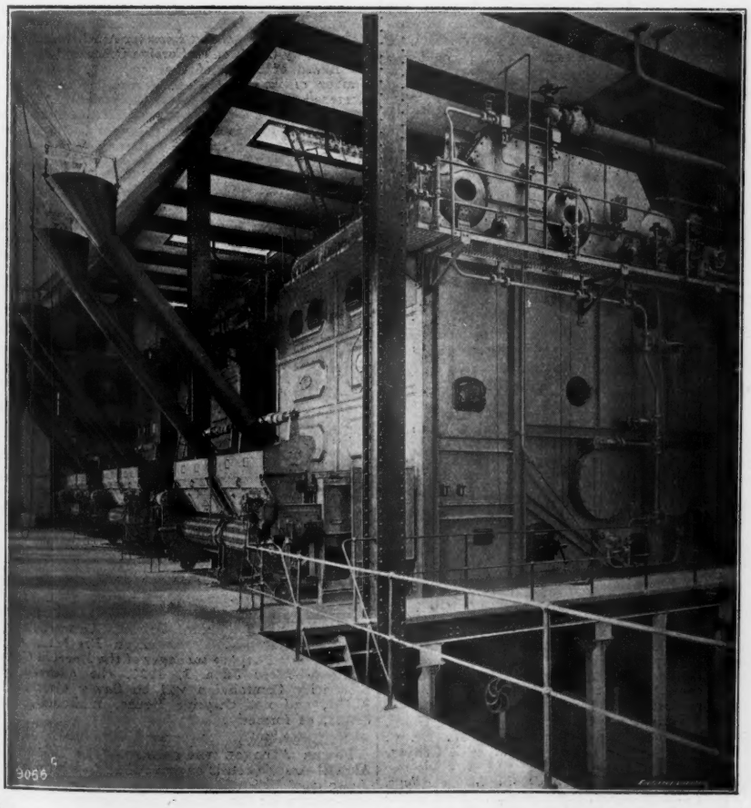


FIG. 7. INTERIOR OF BOILER ROOM.

into the chimney. The soot-scrapers are electrically driven. Davidson fans, located as indicated in Fig. 2, are used for the induced draught, the fans each having an impeller 45 in. in diameter and running at a maximum speed of 480 r.p.m.; at this speed, the draught amounts to $1\frac{3}{4}$ in. water gauge. The fans, which are each driven by a 32-h.p. motor, normally draw the gases through the economisers and discharge them into steel guyed chimneys, but arrangements are made for by-passing the fans and delivering the gases directly into the chimneys if necessary.

The water supply for the station is taken from the town mains, 4-in. services being connected both to the drinking-water and surface-water supplies. As previously mentioned, the water for the circulating system is softened to prevent the formation of hard scale in the condenser tubes, while the feed make-up is dealt with by a P. & B. evaporator. This is of the single-effect type, and is capable of supplying 2,000 lb. of distilled water per hour at a temperature of 212 deg. F. From the evaporator tank, the water is pumped up to a distilled-water tank, whence it flows by gravity to the hot well. The condensate is delivered directly into the hot well, and arrangements are made so that an emergency supply of feed make-up can be taken to the hot well from the softener. From the hot well, the water is drawn by the feed pumps through a Kestner degasser to remove any dissolved oxygen. There are three feed pumps, and the feed range is in duplicate, one being connected to the economisers and the other directly to the boilers; a Crosby automatic pump control is fitted to the feed main. Of the three feed pumps, two are of the turbine type by the Pulsometer Engineering Company, Limited, each having an output of 3,000 gallons per hour against a pressure of 295 lb. per square inch when running at 2,850 r.p.m., while the third is a vertical direct-acting steam pump of the same capacity, made by Messrs. J. and P. Hall.

Coal is delivered to the station in 10-ton trucks on a siding from the Hastings–Ashford line of the Southern Railway, the trucks being handled by means of an electric capstan as indicated in the plan, Fig. 2. The wagons are drawn over an electrically-operated weigh-bridge on to a tipper, which we illustrate in Fig. 6, on this page. The tipper was supplied by Messrs. Aldridge and Ranken, Limited, and is one of their patent gravity type, capable of handling 12-ton wagons. The rails of the tipper are carried on a cradle constructed of rolled-steel joists and supported on cast-steel rockers, so that it can be tilted through an angle of about 40 deg., the wagon being secured by chains and turnbuckles, as will be clear from Fig. 6. The coal is discharged from the wagon into a hopper, from which it is raised by a bucket elevator on to an 18-in. band conveyor running along over the bunkers. The conveyor is provided with a throw-off carriage enabling the coal to be delivered into any one of the three overhead bunkers, each of which has a capacity of 100 tons. The chutes supplying the coal from the bunkers to the stokers can be seen in Fig. 7, and it will be noticed that they are of the lateral-traversing type in order to distribute the coal uniformly across the width of the stoker hoppers. The traversing motion for the chutes is obtained from helically-grooved rollers mounted above the hoppers, as can be seen in Fig. 7, the rollers being driven from the stoker mechanism.

The whole of the switchgear for the new station was supplied by Messrs. Ferguson, Pailin, Limited, and consists of an extra-high-tension board for the 6,600-volt, three-phase system, a high-tension board for the 2,200-volt, two-phase system, and a 400-volt, three-phase board for the power-station machinery. All the switchgear, which is located as shown in Figs. 1 and 2, is of the metal-enclosed, stationary, air-insulated, unit type, and of the non-interlocked pattern. The extra-high-tension board comprises 17 panels, and is arranged to control the three turbo-generators, four 1,000-kw., 6,600–2,250-volt, Scott-connected trans-

former banks, two 250-kw., 6,600–400-volt works transformers, and two main feeders; spare panels are provided for the future 7,000-kw. turbo-generator, above referred to. The 1,000-kw. step-down transformers feed the two-phase system, which is controlled by the separate high-tension board, and the 250-kw. works transformers supply the low-tension works board. Brown-Boveri automatic pressure regulators are provided for each turbo-generator, and all power transformers are protected on the self-balance system; the feeders are equipped with overload protection having an inverse time element on each phase. The usual synchronising arrangements are provided, and a frequency meter is fitted on the synchronising panel. Other instruments which may be mentioned are an ammeter for each phase of the machine equipments, power-factor indicator, indicating watt-meters, and integrating watt-hour meters. A record of the 'bus-bar voltage is obtained by a chart-recording voltmeter located on a swivel bracket at one end of the board.

The high-tension, two-phase board also consists of 17 panels, and is arranged to control the output from the four 1,000-kw. transformer banks, as well as 12 single-phase, two-wire outgoing feeders. There are 11 panels on the low-tension board, which controls the output from the two 250-kw. works transformers, eight power feeders, and one lighting feeder. All the transformers were supplied by Messrs. Ferranti, Limited, and are of the oil-immersed, self-cooled, double-wound, core type with plus and minus 2½ per cent. and 5 per cent. tappings to compensate for voltage variation. They are located in a transformer-room under the switchboards, on the same level as the condenser floor of the engine-room. In the switchboard annexe, between the extra-high-tension and high-tension boards, is located a central temperature-measuring board equipped with a Cambridge distant-reading thermometer operating 56 points. This enables temperature readings to be taken of the steam, flue gas, feed water, &c., from the boiler-house and also from various points on the turbo-generators and condensing plant. The Electroflo steam-flow meters, above referred to, are also mounted on this board. For providing emergency lighting and for operating the trip-gear circuits and turbine speed-control gear, a 100-volt Edison battery of 225 ampere-hours capacity has been installed. This is located, together with a motor-generator for charging it, in a small laboratory which is equipped with apparatus for determining the calorific value of the coal, as well as for chemical analysis, instrument testing, &c. A repair shop is also provided, as well as ample accommodation for the staff and workmen.

From the Broomgrove Station, 10 single-phase feeders have been laid to various existing substations, and to the Earl-street Station, which will be used as a static sub-station and distributing centre for the load in its immediate vicinity. The two-phase switchboard is arranged so that any of these feeders can be plugged in to either phase, but it is intended, at present, to keep the feeders supplying St. Leonards on one phase, and those supplying Hastings on the other; it so happens that, with the present state of the load, an almost perfect balance can be obtained in this way. The feeders referred to were supplied by Messrs. W. T. Glover and Co., Limited, and are of the concentric "Diatrine"-paper-insulated, lead-covered type, served with jute and provided with double steel-tape armouring; 15,400 yards of 0·25 sq. in section have been laid, and 2,200 yards of 0·6 sq. in. section. Three phase current is also supplied at 11,000 volts to the neighbouring town of Bexhill, duplicate feeders, 10,655 yards in length, having been laid for this purpose. These cables are of the three-core shaped-conductor type of 0·15 sq. in. section, the insulation and protection being the same as those of the single-phase feeders. It is proposed to extend the area of supply to include Rye and Winchelsea, on the east, Northiam and Beckley on the north, and Battle on the west, and this area will also be supplied at 11,000 volts from a step-up outdoor sub-station located near the power station.

As mentioned at the outset, the electricity supply of Hastings is, at present, at a frequency of 100 cycles, so that considerable work will be entailed in changing over to the 50-cycle supply. About 300 large motors are connected to the mains, as well as numerous small motors, fans, &c. Some of the former have already been re-wound for the two frequencies, so that when the change is actually effected it will only be necessary to alter the connections and change the pulleys. Wherever possible, of course, the other motors will be re-wound, but in some cases it will be necessary to provide new machines. In any case, a complete change in the form of supply is a difficult and troublesome job, but it is hoped to complete the work in about three months.

In conclusion, it may be of interest to mention that the total capital cost of the new station and plant of 9,500 kw. has amounted to 163,000*l.*, or 17·157*l.* per kilowatt at normal rating. The buildings, however have been designed to house an additional set having an overload rating of 7,000 kw. and a normal rating of 5,600 kw. The estimated cost of this, with another cooling tower, is about 50,000*l.*, bringing the total capital cost to 213,000*l.* and the cost per kilowatt at normal rating to 14·12*l.* These, we think it will be admitted, are very satisfactory figures for a station of the specified capacity at the present time.

HIGH-TENSION ELECTRIC SUPPLY REGULATIONS.

THE regulations with which high-tension electric supply systems must comply under the Electricity (Supply) Acts of 1882 to 1922, and Orders relating to them and all Special Acts have been concisely embodied in a model description of a typical arrangement prepared and published in leaflet form by the Electricity Commission, of Gwydyr House, Whitehall, London, S.W.1. It is stated in this pamphlet that with a three-phase alternating current system of supply at pressures of 6,600, 11,000, 33,000, 49,000 or 66,000 volts, supply will be given only to consumers' premises equipped with transformers, converters, or motors. Otherwise supply is made at medium or low pressures. For high-pressure distribution, alternating current only is used, while for medium and low-pressure service either alternating or direct-current may be used. All alternating current must have a frequency not varying by more than 2½ per cent. from 50 complete cycles per second.

With regard to the mains, these should consist of insulated conductors laid together and enclosed in a lead sheath. Mains may be either braided, compounded, and armoured, and laid direct in the ground; be drawn into pipes or ducts of approved design; or be laid in troughs filled in with composition and covered with hard burned tiles, or other approved protection, held in position by contact with the filling. When the first-mentioned of these alternatives is adopted the cables may be covered with wooden planks 2 in. in thickness and (except for making up and bend pieces), 10 ft. in length, treated with a preserving agent. Reinforced concrete slabs 3 ft. long by 2 in. thick and 6 in. wide, and suitably interlocked so as to prevent lateral displacement, are permissible if preferred, while concrete made *in situ* 3 in. thick, of a minimum width of 9 in. and overlapping by 2 in. on each side, may also be used.

Any joint electricity authority or authorised undertakers within the meaning of the above-mentioned Acts adopting an extra high pressure system of supply of the type outlined must notify the Electricity Commissioners. The latter will advise such authorities or undertakers when the regulations as to extra high pressure for securing the safety of the public, and for ensuring a proper and sufficient supply of electrical energy, have been satisfied. Any extra high pressure system of supply possessing features in contradiction to the system described above will, of course, require to be specially approved.

BOOKS RECEIVED.

Proceedings of the Empire Mining and Metallurgical Congress, London, June 3–6, 1924. Part I. *General.* Part II. *Mining.* Part III. *Petroleum.* Part IV. *Metallurgy of Iron and Steel.* Part V. *Non-Ferrous Metallurgy.* London: Offices of the Congress. [Price 2*l.* 2*s.* net.]

Johnson's Materials of Construction. Rewritten by M. O. WITHEY and JAMES ASTON. Sixth edition. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 30*s.* net.]

United States Bureau of Standards. Scientific Papers. No. 502. *An Improved Type of Wavemeter Resonance Indicator.* By M. S. STROCK. [Price 5 cents.] Technologic Papers. No. 272. *Fire Resistance of Concrete Columns.* By W. A. HULL and S. H. INGBERG. [Price 25 cents.] No. 280. *Reclamation of Gasoline Used in Dry Cleaning.* By C. C. HUBBARD. [Price 5 cents.] Washington: Government Printing Office.

Allgemeine Grundlagen der Elektrotechnik. By Dr. C. MICHALKE. Berlin and Leipzig: Walter de Gruyter and Co. [Price 5 marks.]

The Metallurgy of Aluminium and Aluminium Alloys. By ROBERT J. ANDERSON, B.Sc., Met.E. New York: Henry Carey, Baird and Co., Inc. [Price 10 dols. net.]

The Elements of Machine Design. By S. J. BERARD and E. O. WATERS. London: Blackie and Son, Limited. [Price 10*s.* net.]

Steam Condensing Plant in Theory and Practice. By JAMES SIM, B.Sc. London: Blackie and Son, Limited. [Price 18*s.* 6*d.* net.]

The Year-Book of Wireless Telegraphy and Telephony, 1925. London: Iliffe and Sons, Limited. [Price 15*s.* net.]

Questions and Answers relating to Diesel, Semi-Diesel and other Internal Combustion Engines, Air Compressors, &c. By JOHN LAMB. Second edition, revised and enlarged. London: Charles Griffin and Co., Limited. [Price 5*s.* net.]

THE LATE MR. G. F. MACKROW.

BY the death of Mr. George Frank Mackrow, which occurred at his residence at Whitley Bay on Saturday, May 23, the engineering and shipbuilding firm of Messrs. R. and W. Hawthorn, Leslie and Co., Limited, of Hebburn-on-Tyne, lost one of their oldest and most valued servants.

Mr. Mackrow, who had reached the age of 73 years, started on his engineering career in London by serving an apprenticeship with the Thames Ironworks and Shipbuilding Company, Blackwall. No sooner had he completed his articles than he was given responsible work to do, for he was offered and accepted the post of assistant naval architect to Messrs. J. and G. Rennie, shipbuilders and engineers, of Greenwich. Here his work proved his worth, and he rendered valuable service for ten years. The Thames Ironworks then approached him to return to them as chief assistant to his father, Mr. G. C. Mackrow. Later he spent five years in Bombay, where he held the post of Chief Constructor at H.M. India Marine Dockyard. The accumulated experience of these years was later put to valuable service in the work of Messrs. R. and W. Hawthorn, Leslie and Co., Limited, and for thirty-one years he was solely engaged upon naval construction and design. To him much of the success obtained with the many notable war vessels built by the company must be credited. Mr. Mackrow was elected a member of the Institution of Naval Architects in 1893.

CIVIL ENGINEERING IN PALESTINE.—It is announced by the Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, that the Chief British Representative, Trans-Jordan Government, Amman, Palestine, is desirous of receiving British Catalogues, lists, and pamphlets which are of interest in connection with road, bridge, and building construction, the erection of water supply systems, and the laying-down of irrigation, drainage, and sanitation works.

THE SWEDISH IRON AND STEEL INDUSTRY.—The issue of the *Swedish Economic Review* for April, 1925, published quarterly by the Swedish Foreign Office and compiled by the Board of Trade of that country, states that the number of iron and steel furnaces in operation has decreased progressively since November, 1924. The output for the first two months of 1925 was consequently well below that for the corresponding period of the previous year. This state of affairs is partly due to the fact that the insignificant snow-fall during last winter gave rise to difficulties in the transportation of charcoal to the works, which is usually effected with sledges.

SPECIFICATION FOR BUS-BARS AND CONNECTIONS. Early last year the British Engineering Standards Association issued a specification for the marking of switchboard bus-bars and connections. The quality of the metal used, the limits of temperature rise and current density, notes on jointing between conductors and recommendations regarding the sizes of flat and round copper and aluminium bars have, however, formed the substance of a new publication entitled "British Standard Specification for Bus-Bars and Connections Constructed of Bare Copper or Aluminium," and numbered 159–1925. Copies of this leaflet may be obtained at a cost of 1*s.* 2*d.*, post free, from the offices of the Association, at 28, Victoria-street, London, S.W. 1.

PERSONAL.—Mr. A. H. Darker, chief electrical engineer to Messrs. J. Stone and Co., Limited, of Oceanic House, Cockspur-street, London, S.W.1, has returned to London after an extensive tour abroad.—The Selson Engineering Company, Limited, of Selson House, 83 and 85, Queen Victoria-street, London, E.C.4. have now occupied new premises at 26 and 28, Charles-street, London, E.C.1.—At a recent meeting of the Board of Directors of the Marconi International Marine Communication Company, Limited, Mr. Frederick Sandland Hayburn was appointed manager of the company, while Mr. James Archibald Carswell, managing director of Messrs. Macnaughton Brothers, Glasgow, was appointed deputy manager of the Marconi Company, Limited.—After June 1, 1925, the address of the Electricity Commission will be Savoy Court, Strand, W.C.2, and not Gwydyr House, Whitehall, London, S.W.1, as formerly.

POWER ALCOHOL FROM BEET.—The British Power Alcohol Association is endeavouring to secure an extension of the British Sugar (Subsidy) Bill of 1924, to cover beet grown for the production of power alcohol. It is pointed out that this fuel could be made in small distilleries spread all over the country and capable of dealing with quantities of from 200 to 250 tons of beet per day. For economic working, a sugar factory requires a daily minimum of 1,000 tons of beet. These factories can therefore, only be established in districts in which a large acreage is devoted to the cultivation of the root crop. On the other hand, the beet grown as a rotation crop in limited areas would provide the raw material for the small alcohol plants. The association are of opinion that if the industry is assisted in the early stages, Great Britain would eventually be able to supply about 40 per cent. of her present motor fuel requirements. Power alcohol when mixed with petrol in any quantity up to equal volumes, gives a clean and efficient motor fuel.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though Cleveland pig-iron is not very plentiful, quotations continue to move downward, largely owing to the cheap parcels of Continental iron that are offered abroad. There are sellers of No. 1 at 80*s.*; and customers state that they experience no difficulty in placing f.o.b. orders for No. 3 g.m.b. at 75*s.*, whilst No. 4 foundry has dropped to 74*s.*; and No. 4 forge to 73*s.* These are the lowest quotations for ten years.

Hematite.—A few inquiries are circulating for East Coast hematite iron, and though producers are hampered by rather heavy stocks, they are disinclined to make price concessions. Up to 81*s.* is still asked for No. 1, and sellers continue to quote mixed Nos. at 80*s.* 6*d.*

Foreign Ore.—Imported ores are very difficult to dispose of, and consumers are not taking full supplies against running contracts. In the continued absence of transactions, market rates remain nominal on the basis of best rubio at 22*s.* c.i.f. Tees, but sellers would, no doubt, give favourable consideration to offers on lower terms.

Blast-furnace Coke.—Durham blast-furnace coke is in only very moderate request. There are sellers of good average qualities at 22*s.* delivered to local consumers.

Manufactured Iron and Steel.—There is not much moving in manufactured iron and steel. For some descriptions of material, overseas inquiries are rather better, and heavy sales of galvanised sheets have been made to India. Iron rivets have dropped 15*s.*, and steel rivets have been lowered by 20*s.*, but prices of other commodities have not been quotably altered. Common iron bars are 11*l.* 12*s.* 6*d.*; iron rivets, 13*l.* 10*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.*; steel billets (medium), 8*l.* 15*s.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 8*l.* 5*s.*; steel rivets, 13*l.*; steel joists, 8*l.* 5*s.*; heavy sections of steel rails, 8*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 16*l.* 15*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No change can be reported in the ruling conditions in the Scottish steel trade this week. Very keen competition is general amongst makers for any lots on offer, but, in most cases, these continue on the small side, as consumers are confident that quotations will ease further before there is any upward tendency. Orders are difficult to secure, with the result that much plant is out of commission at present. Shipbuilders are specifying for very little material of any kind, and other users are also not in a position to place much business. Export trade is likewise exceedingly poor. In the black-sheet trade, while there is quite a fair amount of work booked, the demand at the moment, although better is not as good as it might be. For galvanised sheets there is a good market, and producers generally are likely to be fully employed until the Fair holidays in July. Few branches of industry are in a like position. The following may be taken as the current prices:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 17*s.* 6*d.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets, $\frac{3}{16}$-in. to $\frac{1}{8}$-in., 10*l.* 5*s.* to 10*l.* 10*s.* per ton, all delivered at Glasgow stations.

Malleable Iron Trade.—A depressed state prevails in the West of Scotland malleable-iron trade, and no improvement ahead can be seen. The current demand is of the day-to-day variety, which does not inspire any confidence as to the future. Inquiries are poor, and for small tonnage principally. In the re-rolled steel branches, a slightly better demand is general, but competition is keen. The price of "Crown" bars is 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—There has been little movement in the Scottish pig-iron trade over the week, and a very poor demand exists. Not only is the home trade consuming little, but export buyers are not sending forward any inquiries of consequence. To-day's market quotations are as follow:—Hematite, 4*l.* 10*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 8*s.* per ton; and No. 3, 4*l.* 6*s.* per ton, both on trucks at makers' yards. One of the furnaces at the works of Messrs. Merry and Cunningham, Limited, at Ardeer, has been blown in. This action has been taken solely because the firm has run short of a special quality of iron.

Wages in the Iron Trade Reduced.—The following intimation has been made by Sir John M. MacLeod, Bt., C.A., Glasgow, to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation Board:—"In terms of the remit, I have examined the employers' books for March and April, 1925, and I certify that the average net selling price brought out is 11*l.* 19*s.* 4·15*d.*" This means that there will be a decrease of 2½ per cent. in the wages of the workmen.

Notes.—Shipbuilding circles are interested in the announcement that Messrs. Furness, Withy and Co. are again contemplating the ordering of new vessels. Tender forms have been issued to a number of firms, and it is understood that contracts for four 10,000-ton vessels are likely to be given out. Diesel engines will be the motive power. The Blue Star Line intend to order nine new vessels, instead of eight, as reported. The Clyde has already secured orders for two, and the Tyne two, but five more have yet to be placed.—The North-British Locomotive Company Limited, Hyde Park Works, Glasgow, has secured a contract for 35 locomotives for the Egyptian State railways. The remaining lot of the 50 to be ordered has been placed in Germany. The promise of earlier delivery weighed in favour of the larger part of the order coming here.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, May 23, amounted to 447 tons. Of that total, 362 tons went overseas and 85 tons coastwise. For the corresponding week of last year, the figures were 156 tons foreign and 85 tons coastwise, making a total shipment of 241 tons.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The heavy trades are barely holding their own, and as, from the standpoint of new business, the slackest season of the year is approaching, there is no prospect of a favourable change in the early future. Whether the Whitsuntide shut-down will be of longer duration than usual will be determined by the state of order books at individual concerns. As, however, operations, in many instances, have been unprofitable over the past six months, it is not unlikely that a large number of steelworkers of various grades will be paid off. New business was rarely so scarce in raw and semi-finished materials. Deliveries under contract coming into this district are fairly substantial, but there appears to be no disposition to renew arrangements for forward supplies, except at markedly lower rates. Basic steel makers are feeling the effect of competition most acutely, and, according to careful students of the position, are increasing their losses. There is scarcely any market for any description of pig-iron or scrap. Foreign makers are supplying the greater weight of basic iron utilised in British foundries. Holders of scrap are offering minor concessions to tempt steelmakers, but the latter, in turn, are holding out for still lower rates. There is no change in the depressed state of the Lincolnshire steel trade. Makers of axles, tyres, springs, and general railway stores have booked fresh orders from British companies. Their difficulty is to obtain sufficient export business, in face of foreign underselling, to operate plants profitably. There is still a brisk demand for gardening and farming tools, as well as for picks and shovels. The light foundries are turning out substantial supplies of building ironwork, though trade union restrictions militate against the potential demand. The Postmaster-General, Sir William Mitchell-Thomson, has promised to attend the next quarterly luncheon of Sheffield Chamber of Commerce, on June 17.

South-Yorkshire Coal Trade.—Several branches are beginning to reflect, in pit-head quotations, the easier conditions generally prevailing. The seasonal shrinkage in the house-coal demand both from London and the Provinces is marked by a fall of 1*s.* 9*d.* per ton in Derbyshire best brights, and of 1*s.* 6*d.* per ton in Derbyshire best house coal. Steam coal prices are maintained with difficulty in face of weakness on export account. Further weakness in cobbles and nuts is a general feature, with the result that Derbyshire best small nuts have been reduced 2*s.* per ton. The coke position is generally in favour of buyers, and quotations are largely nominal. Quotations:—Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 24*s.* to 27*s.*; Derbyshire best house, 22*s.* to 24*s.*; Derbyshire best large nuts, 18*s.* to 22*s.*; Derbyshire best small nuts, 12*s.* to 14*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; and smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

THE INSTITUTE OF PHYSICS.—At the annual meeting of the Institute of Physics, held on May 25, at the Royal Society, Sir William H. Bragg was elected president, in the place of Sir Charles A. Parsons, and Major C. E. S. Phillips, treasurer, in the place of Sir Robert Hadfield. The other new officers elected were Professor C. L. Fortescue and Mr. R. S. Whipple, vice-presidents, and Professor E. N. da Costa Andrade and Mr. C. C. Paterson, non-official members of the Board. Professor A. W. Porter, of University College, remains honorary secretary, and Mr. F. S. Spiers, of 90, Great Russell-street, W.C.1, secretary. Sir Charles Parsons, the retiring president, did not deliver an address—having done so at the close of his first year of office—but drew an interesting comparison between the work of the artist on canvas and the activities of the workers in physics and the arts and sciences. There were many points of similarity, some of identity, but there was the difference that the artist on canvas, accurate in the main, introduced inaccuracies in order to infuse soul, imagination and life into his work, while the scientist held accuracy to be fundamental, and endeavoured laboriously to eliminate errors, including personal errors of observation; though urged by imagination, the physicist was schooled to accuracy. Discoveries had often been made by attention to "the next to nothing things." Taking pains was not much use without accuracy; but genius, guided by modern science, was one of the greatest factors in the advance of civilisation. Sir Charles also referred in appreciative terms to the work, capacity and self-sacrifice of the late Sir George Beilby, one of the distinguished members the Institute had lost during the past year.

NOTICES OF MEETINGS.

THE SOCIETY OF CHEMICAL INDUSTRY: CHEMICAL ENGINEERING GROUP.—To-night, at 8.15 p.m., at the Chemical Industry Club, 2, Whitehall-court, S.W.1. Annual General Meeting.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Wednesday, June 3, at 5.15 p.m., at Albemarle-street, W.1. "Passage of Electricity through Vacuum Tubes" (Lecture III.), by Professor Richard Whiddington.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, June 3, at 6 p.m., at Savoy-place, Victoria Embankment, W.C.2. Wireless Section Meeting. "The Effect of Wave Damping in Radio Direction-Finding," by Mr. R. L. Smith-Rose, Ph.D., M.Sc.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: SOUTHERN DISTRICT.—Saturday, June 6, at 11 a.m., at the Town Hall, Reading. Discussion on "Tests on the Air-Ejector Sewage System at Gosport," by Mr. Cliffe.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Proposed Dry Dock Amalgamation.—Negotiations were conducted during the past week for the amalgamation of the Cardiff Channel Dry Docks and Pontoon Company, Limited, and its subsidiary concerns, the Bute Shipbuilding and Engineering Company, Limited; the Mercantile Pontoon Company, Limited; the Barry Graving Docks and Engineering Company, Limited; and the Tredegar Dry Dock and Wharf Company, Limited, with Messrs. Elliot and Jeffery, Limited, owners of the Windsor Slipways between Cardiff and Penarth. The negotiations have, however, been ended without any agreement being reached. Had the fusion of interests been ratified, Mr. John Elliot, partner in the firm of Messrs. Elliot and Jeffery, was to have been appointed managing director of the combine, which would have controlled more than two-thirds of the dry-docking accommodation and plant in South Wales.

The Coal Trade.—A number of additional pits have been closed down during the past week, some because of failure to negotiate new price-cutting lists, and others because of the unremunerative state of trade. Despite this, outputs are again in excess of the demand, and with a shortage having developed in the supply of shipping, some collieries are finding it difficult to secure a quick clearance of current outputs. The general inquiry is small and confined to cargoes and bunkers for boats likely to sail before the holidays. The demand for late loading, too, is restricted, with prospective buyers indicating lower figures, but up to the present salesmen prefer to await developments before committing themselves. Even the better class large steam coals, which of late have been relatively active and firm, have developed an easier tendency, and best Admiralty large is now available at 26*s.* to 26*s.* 3*d.* with seconds from 25*s.* to 25*s.* 9*d.*, while Monmouthshires rule from 23*s.* 6*d.* to 24*s.* 6*d.* for the best qualities, with the inferiors down to 22*s.* 6*d.* Smalls, too, are more than sufficient to meet shippers' requirements, despite the fact that collieries, in view of the holidays, are banking stocks for use under their own boilers. Shipments of coal as foreign cargo from South Wales in the past week, totalled 503,710 tons, compared with 461,030 tons in the preceding week. France took 117,660 tons, Italy 45,460 tons, Algeria 67,230 tons, Egypt 37,470 tons, Portugal 29,450 tons, and Spain 30,610 tons. Shipments from Cardiff reached 296,040 tons, Newport 100,100 tons, Swansea 64,200 tons, Port Talbot 38,800 tons, and Llanelly 4,570 tons.

Iron and Steel.—Generally, there is an improving demand for Welsh tinplates, with the Continent buying more readily round 20*s.* 3*d.* South America and Australia are also good customers, but at the moment the Far East market is quiet. Shipments of iron and steel goods in the past week totalled 12,301 tons, compared with 18,106 tons in the previous week. Exports of tinplates and terneplates amounted to 7,921 tons against 10,055 tons, blackplates and sheets 1,117 tons against 1,329 tons, galvanised sheets 2,178 tons against 5,168 tons, and other iron and steel goods to 1,085 tons against 1,554 tons.

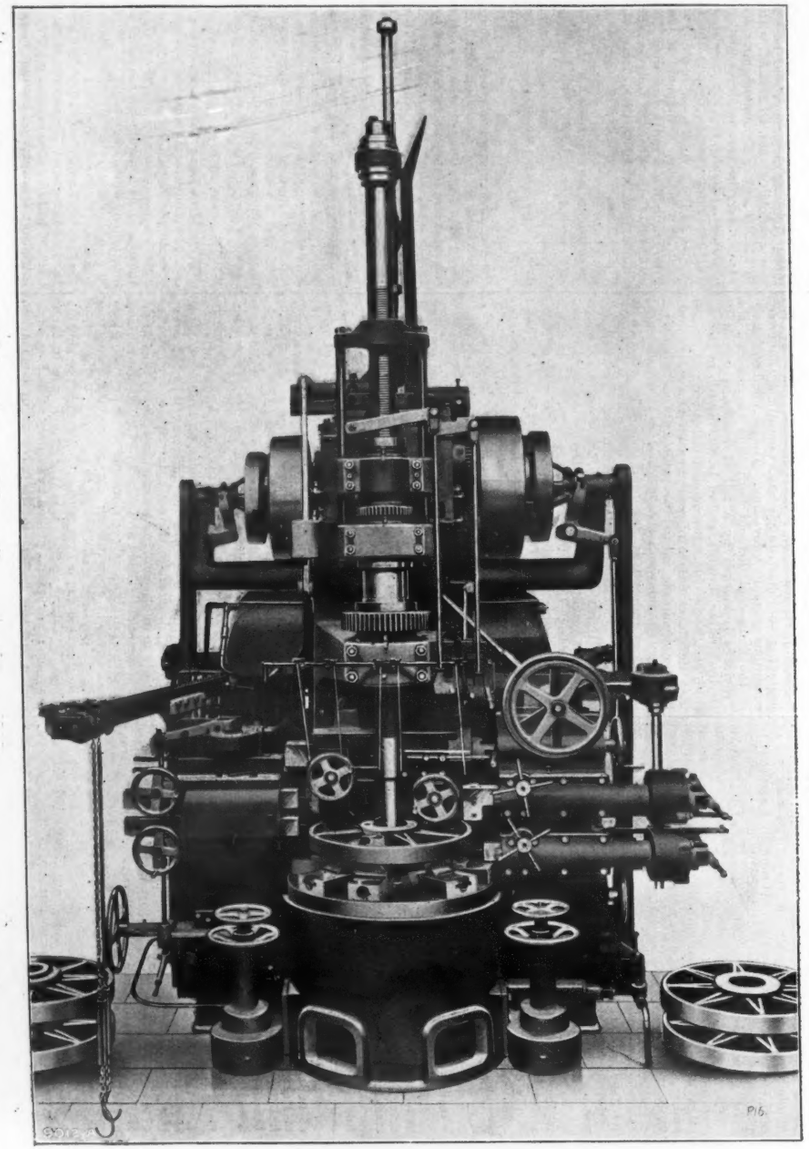
GENEVA MOTOR AND CYCLE SHOW.—A confidential report on the second Geneva Motor and Cycle Show has been prepared and forwarded to the Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1. The work is issued to firms entered on the Department's Special Register, but other United Kingdom firms can obtain a copy of the report on application to the Department.

FOUR-MILE BELT CONVEYOR FOR COAL.—After severe service tests, a coal conveyor system of the belt type, operating at East Roscoe, Pennsylvania, U.S.A., has been considered a success in practice. This conveyor, which consists of 20 separate belts, carries coal from a central location, at which wagons are unloaded, to waiting barges in the Monongahela River, a distance of more than 4 miles. Power is supplied by 20 motors, the latter constructed and installed by the General Electric Company of America. These motors range in horse-power from 50 to 175. The belt conveyor, chosen in preference to railway transport on account of peculiar problems of topography, coupled with the necessity for lifting coal through a fair height, can handle an average weight of 1,229 tons per hour, and requires 0·17 h.p. per 100 tons of coal per 100 ft. of travel.

VERTICAL DUPLEX TOPPING, BOSSING AND BORING MACHINE.

MESSRS. CAMPBELLS AND HUNTER, LIMITED, ENGINEERS, LEEDS.

(*For Description, see Page* 665.)



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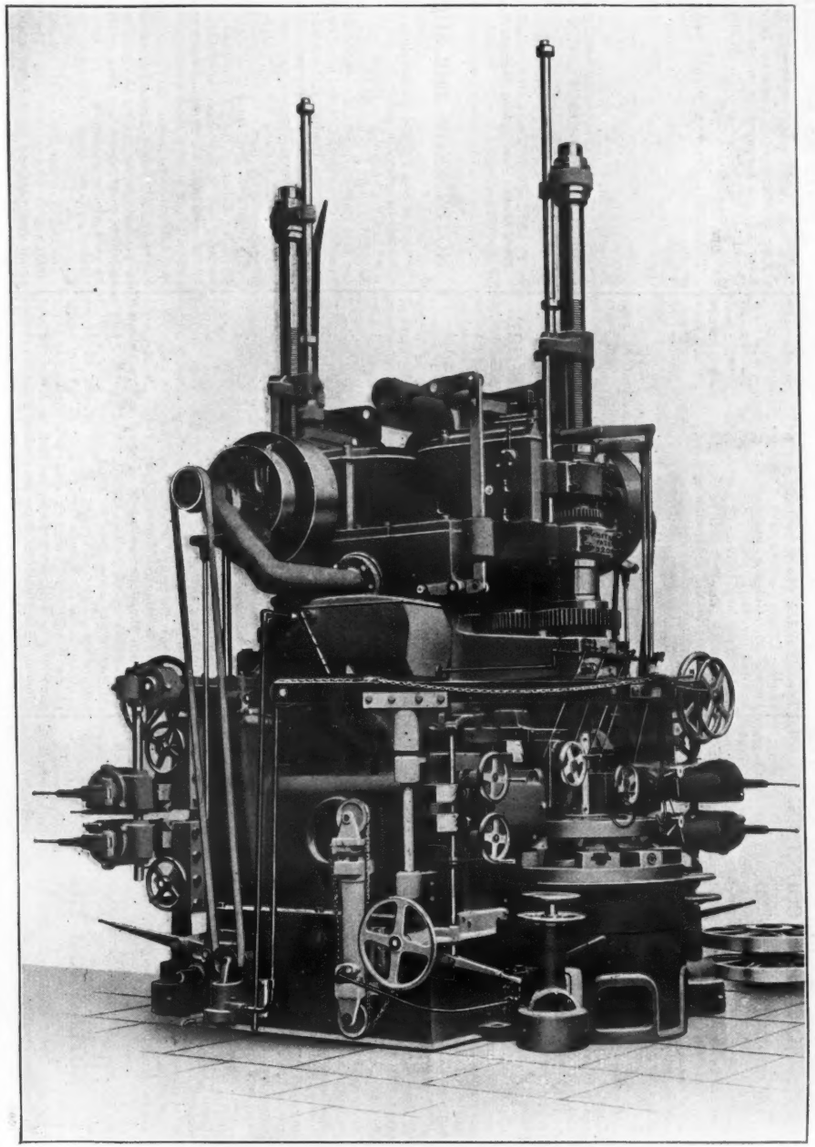

FIG. 2.

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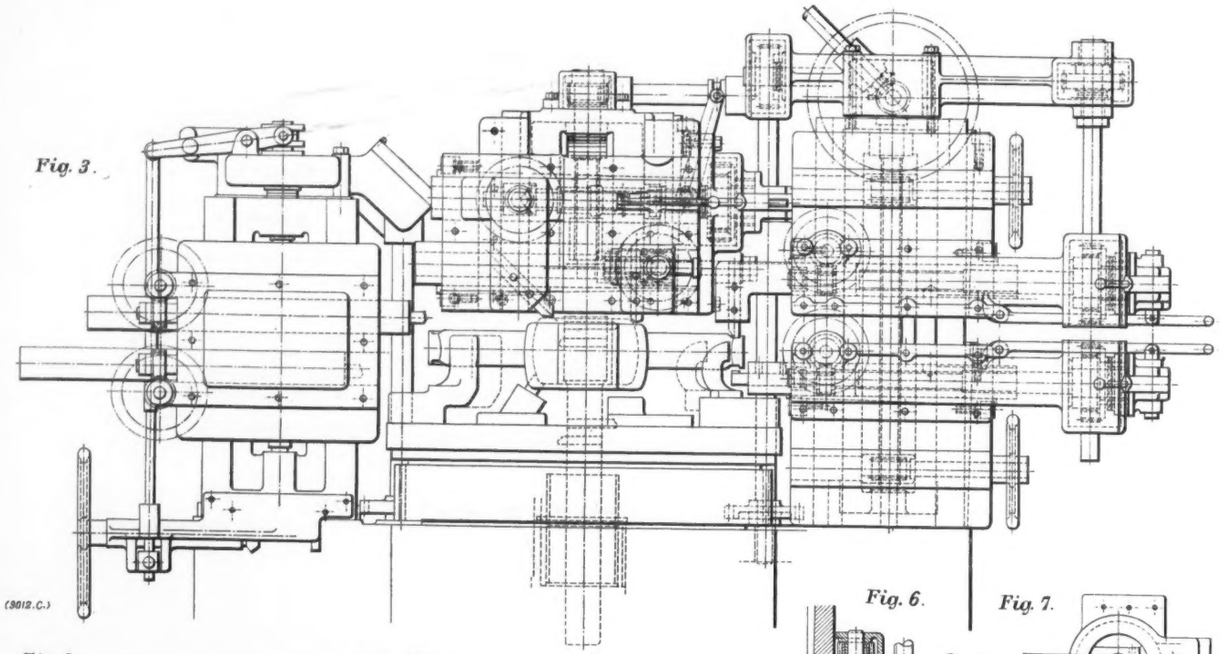

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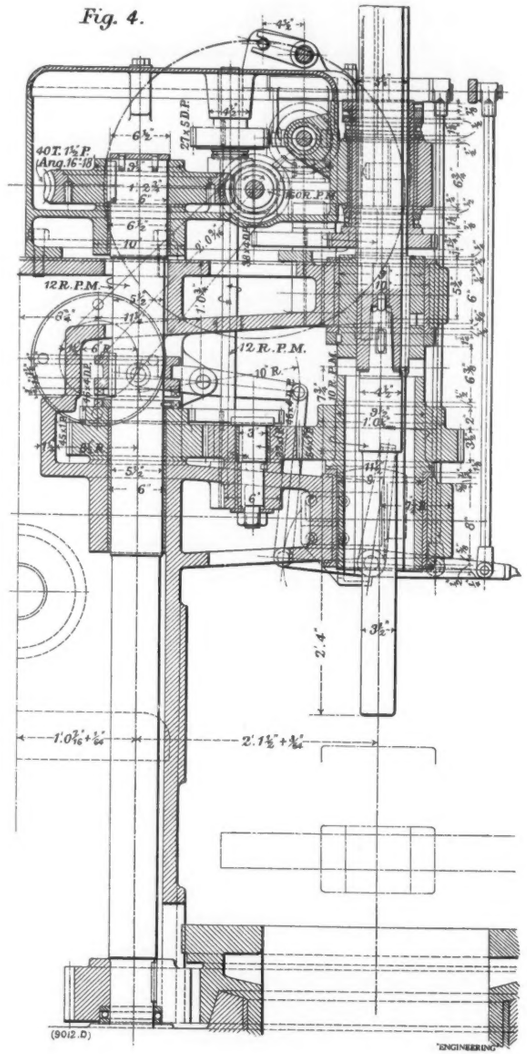

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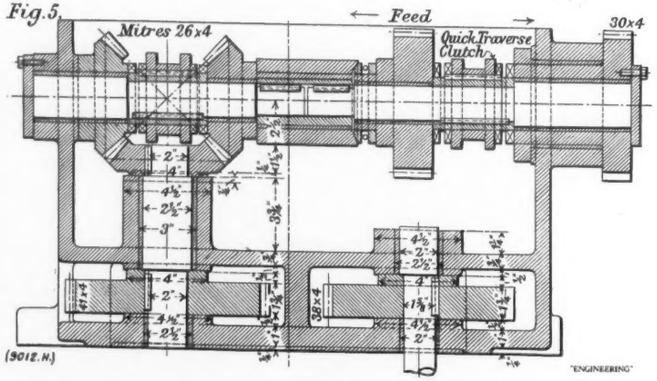

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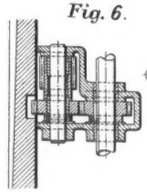

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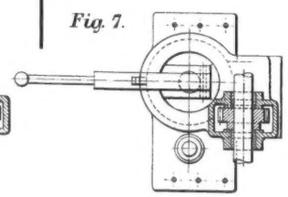

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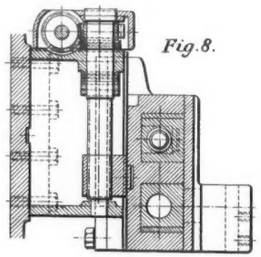

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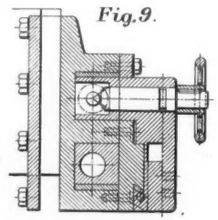

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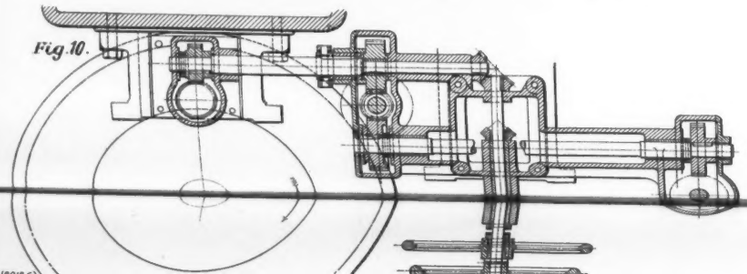

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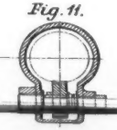

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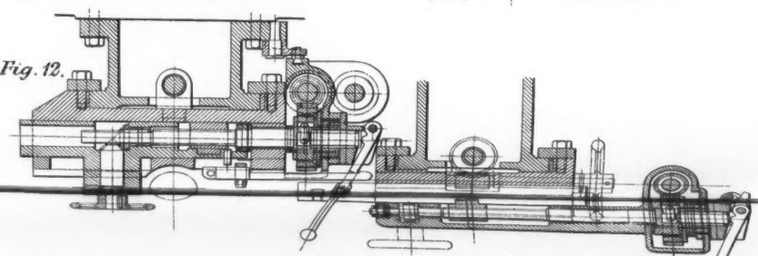

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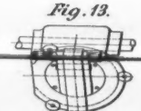

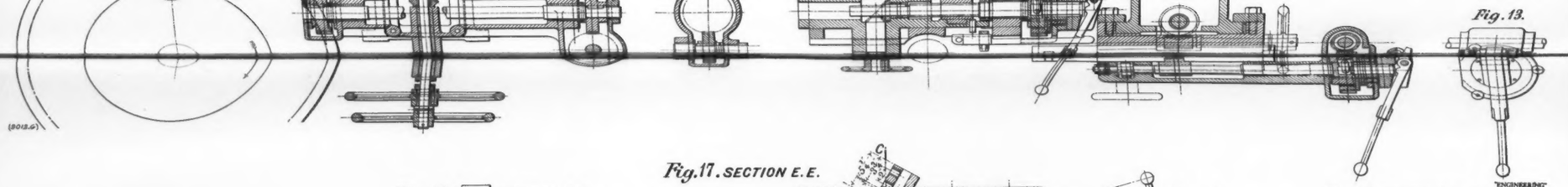

Fig. 13.

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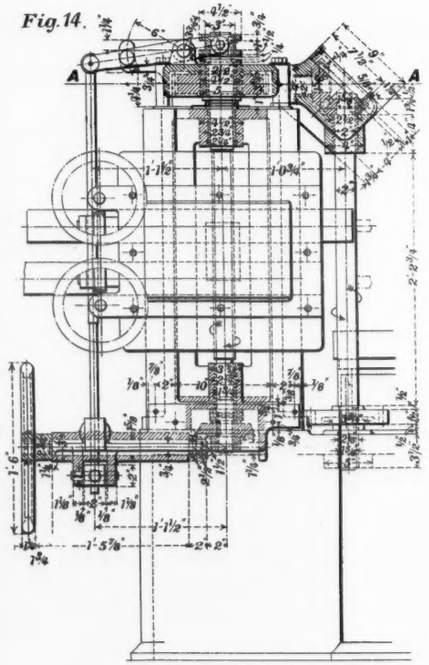

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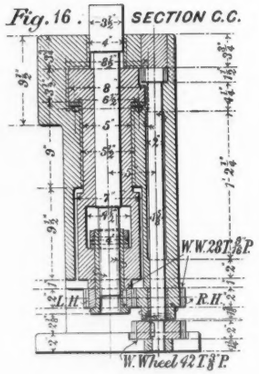

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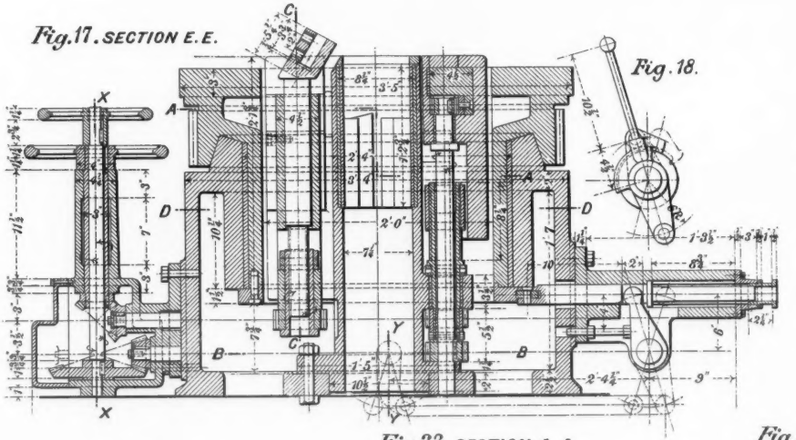

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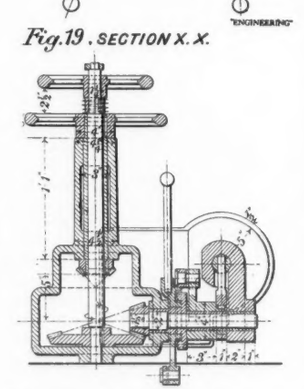

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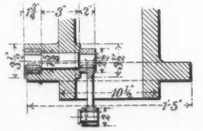
Fig. 20. SECTION Y.Y.



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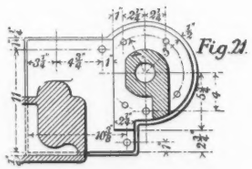

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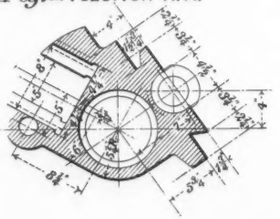

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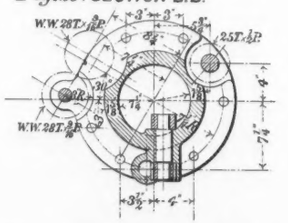

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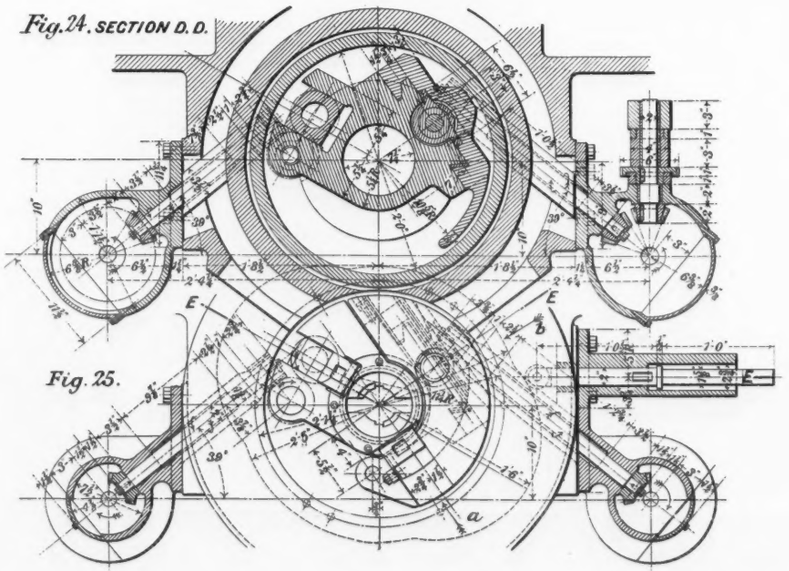

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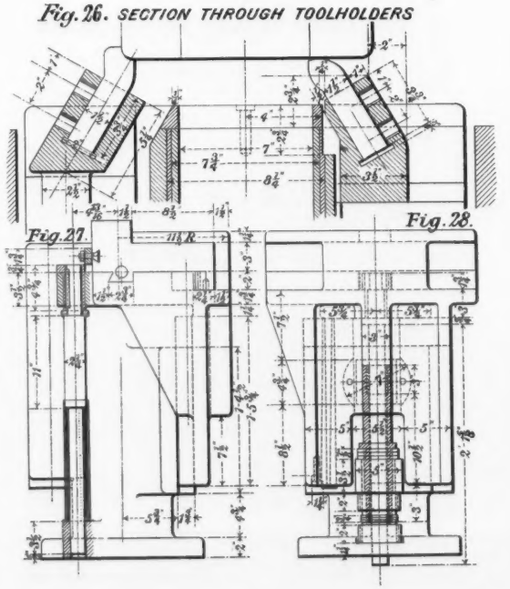

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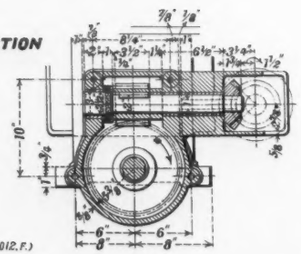
Fig. 15 SECTION A.A.



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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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ENGINEERING.

FRIDAY, MAY 29, 1925.

THE STATUS OF THE ENGINEER.

DOCTORS and lawyers are universally regarded as professional men and are protected by law against the competition of irregularly trained rivals, no matter what the qualification of the latter may be. It is, of course, notorious that certain gifted but self-taught specialists are greater experts in dealing with strains and dislocations than is the average surgeon, whilst many solicitors' clerks have, in virtue of prolonged experience, a better knowledge of law than some of their principals. The bone-setter is not allowed to claim the title of a doctor, nor is the experienced law clerk permitted to pose as a solicitor, nor to act as a barrister. Probably in both cases there is a balance of public advantage in these restrictions, though were access to the bar as open in this country as it is in America it is probable that no small proportion of those who have taken up the profession of labour agitator would have applied their undoubted talents to the law. Every decade sees the establishment of additional close professions, perhaps not always with adequate reason. The engineer whose responsibilities are at least equal to those of the doctor and lawyer still remains unprotected, and the labourer, who is described on the charge sheet of a police court as an engineer, has as much legal right to the title as the head of the profession.

From the comprehensive report on the status of engineers and architects, which was published some months since by the International Labour Bureau, it would appear that this state of affairs is not universal. In many countries heavy penalties are prescribed for the unauthorised use of the title of engineer, and in all these countries special stress is laid upon academical qualifications. In England and America and also in France there are no such restrictions and in all three countries it is recognised that the possession of a diploma is no proof of professional competence and that many able engineers have acquired a very adequate knowledge of their profession by simply practising it.

Engineering has not yet been reduced to a science, and if past experience holds good it is never likely to be. Some branches of the profession must always partake much more of the nature of an art than of a science, as was strikingly exemplified during the American war of succession when an experienced contractor replaced a railway bridge before the professional corps of engineers had thought out their preliminary plans. In fact, what a maintenance engineer needs is experience and not very much else. Again, when new industries are established certain men grow up with them, and have often to "skirmish ahead of the army" of science. This was notably the case in water works engineering and the conditions were repeated when the heavy electrical industries were founded. The late C. E. L. Brown, for example, had no academic qualifications, but this did not prevent him from being one of the founders of modern methods of electric power distribution.

By a law recently passed in Italy, a man with similar qualifications will not in future be allowed to describe himself as an engineer and there has been similar legislation in Hungary. The Austrian laws also prescribe drastic penalties for the irregular assumption of the title of engineer. It is very improbable that any similar course will be taken here or in America. In both countries the standing of an engineer is largely gauged by his membership of certain technical societies, which are careful to accord full membership only to fully qualified men, though they are indifferent as to how these qualifications may have been gained. In France, too, the opposition to proposals for restricting the title to graduates, comes mainly from the engineers themselves and, in fact, speaking generally it would seem that the movement in favour of such a course is strongest in countries which are the least industrially developed. In certain other countries in which the restrictions are less stringent than in Italy or Hungary, there are regulations providing that certain technical officials must be graduates from recognised engineering schools. This holds good in Germany and also in Spain, and the same policy has been adopted in certain of the republics of Latin America.

From the report compiled by the International Bureau it appears that the complaint is common that graduates from the technical schools receive at the outset salaries which seem very small in view of the prolonged course of study required for the diploma. This is quite as arduous as that demanded from the medical student, but the latter has far better prospects in the matter of pay on completing his course. There is, however, one important point to be borne in mind, viz., that even the clever engineering student is not called upon at the outset of his career to do work in which his special acquirements might be valuable. He is paid accordingly for the work he does and not for that which he could do. Complicated calculations in statics, for example, are not handed over to a newly appointed junior no matter what his academic qualifications may be, and the work he is given at the outset will probably make little demand on his academic training.

So far as Great Britain is concerned there has been a very great improvement in salaries of juniors during late years. In times past the average draughtsman was distinctly underpaid, considering the responsible character of his work. There was, it is true, no dearth of candidates for a stool in the drawing office, but the abler of these regarded the position merely as a stepping stone to administrative positions. The report of the Labour Bureau attributes the improvement in drawing office conditions in this country mainly to the strength of the various professional associations. Some of these associations have also rules as to the length of the working week, and there is a movement to reduce it to 38 hours. In America, on the other hand, drawing office hours are in some cases as much as 10 a day, and it is reasonably certain that this is excessive for this class of work, and that a greater output would be obtained were the number reduced. The eye strain is very considerable, and if the hours are too long the worker unconsciously adjusts himself to them by reducing his output to what he can permanently maintain. Moreover, so far

as administrative posts are concerned it is probably true that much of the most important work is done after office hours.

Another point touched on in the report is the difference in the practice of different countries in the matter of patents. In France, in particular, complaint is made that employés are often unfairly treated in this regard. It is, of course, quite a common condition of engagement that inventions made in the service of a firm must be vested in the latter. So far as private manufacturing firms are concerned this regulation, if reasonably worked, probably seldom involves real hardship, and, in fact, a draughtsman is expected as part of his routine to show a certain amount of ingenuity. It is, in short, impossible to draw a hard and fast line between design and invention.

The claim is sometimes made, however, that firms have a right to the ideas of their employees whatever the duties naturally pertaining to the position held. This plea cannot be defended. As an instance in point, the case of the Ashley deep well pump might be cited. This was brought out when its originator was in the service of the East London Water Works Company, but the design of pumps was no part of his normal duties, and no claim could fairly be made for the transfer of the patent to his employers. Again, in engaging a draughtsman, the salary paid cannot be considered as covering more than what, in the language of the now defunct warrants market, may be designated as a "good merchantable brand" of ingenuity. Had Mr. Michell been engaged as a draughtsman in a marine engineering establishment it would have been unreasonable to demand the transfer to his employers of the patent for his thrust block. If the attempt be made to apply such a rule to revolutionary improvements designed by an employé the latter is apt to protect himself by resigning before he patents any specially promising idea. An instance of this kind is mentioned in the Labour Bureau report as having occurred in America, where an engineer being required by his contract of engagement to transfer any patents he might take out to his firm, resigned when he saw how to effect a really important improvement in manufacturing methods. He then patented his ideas, and sold his rights to a competing firm.

As already stated, so far as minor inventions are concerned, the provision that patents must be vested in the employer probably involves few cases of real hardship. A good designer is certain of promotion, and thus even if patents for his ideas are vested in his firm he does receive a *quid pro quo*. In government or municipal services, however, salaries have a general resemblance to the laws of the Medes and Persians in that they alter not. It is, in fact, commonly the appointment that is paid and not the individual. This precludes any adequate recognition of special ability, and it is thus unreasonable to claim the vesting in the department or in the municipality, of patents taken out by employés not specially engaged in specific research work. In the past the post office regulations have distinctly discouraged ingenuity on the part of their technical staffs. Until the telegraphs were taken over by the Government, three-fourths of the improvements in the art originated here. Subsequently, practically every new idea was imported, although in submarine telegraphy, which still remained under private control, we continued to play a leading part in the advancement of the art.

THE IRON ORES OF ENGLAND AND WALES.

FROM the time that the genius of Abraham Dorley taught the world how to manufacture iron by the use of mineral fuel the production of machinery and of the materials that production demands have gone hand in hand. Increased demand stimulated supply, giving to Great Britain the foremost place among the world's iron producers. The demand for particular grades of ore, varying with the processes of manufacture, has been met either by the ingenuity of chemists or the facilities of transport, and there has been every inducement to be content with the commercial analyses of the ores, which, however satisfactory they proved to the metallurgist, threw little light on the genesis and history of the rocks composing the deposits. The development of new mining areas both in Europe and America has led to more thorough and refined research, raising new problems whose solution cannot be regarded as complete without comparison with the petrography of the British iron ores whose study needed further investigation. The Geological Survey took the necessary action in 1917, and began a systematic investigation of the stratigraphy of the ore deposits in various mines, publishing the results in a series of reports; the latest deals with the petrography and chemistry of the bedded iron ores in England and Wales.*

Whence came the iron ore in the mines which have conferred such advantages on English manufactures in the past? Were the ironstones originally limestones in which the calcium carbonate has been replaced by carbonate of iron, derived from iron-bearing solutions percolating through the rock? Such a view has not been without its adherents, and a certain amount of evidence in its favour may be found in our geological museums, but the author does not share the opinion, nor is it generally held, despite certain past reputations. It is asserted prominently and without hesitation that the bedded ores were deposited substantially in their present condition and were not formed by substitution or replacement. The bedded ores represent a distinctive class of sedimentary rocks of marine, estuarine or deltaic origin, and the problem of their origin becomes that of the precipitation of insoluble compounds of iron in waters which continually receive fresh supplies of that metal from the denudation of land areas.

There is little use in pursuing old clues or tracing the arguments on which conclusions have rested, for the problem widens very materially. Long since it was recognised that the "clay ironstone," in addition to the carbonate, contained a ground mass of silicates of iron of uncertain composition, and so far back as 1910 Stead wrote, "It is a difficult matter to say what is the chemical constitution of the argillaceous matter forming about one-third of the Cleveland ironstone. There are probably many silicates, including silicate of iron. The field is open for research in this direction." The challenge thrown down has been taken up, and on the Continent some very admirable work has been done, in which the importance of the chloritic silicate, chamosite, was recognised, but the old fallacy of tracing the existence of silicate to "secondary" minerals resulting from the alteration of the original deposits was not uprooted. Mr. Ennos and Mr. Sutcliffe, of the Survey Laboratory, by confining their attention to the ooliths and to the carbonates and "green silicates" in the ground mass, have achieved very valuable results and made a considerable advance. No small portion of their success arises from the care bestowed on the preparations of the sections of the ores. The problem presented to them was to find an acid of such strength that the carbonates and chamosite could be easily and readily dissolved, while under the same conditions the other minerals were left practically unattacked. Owing to the nature of the mixed deposit, the task was difficult, but it was satisfactorily accomplished, and Mr. Hallimond is able to say that it has not been necessary to omit the description of any rock on the ground of its unsuitability for sectioning. The method of mechanical treatment of the rock and of the estimation of the chlorite in sedimentary rocks is fully described in an appendix, and 42 photo-micrographs of typical structures attest its success.

The mineralogical forms in which the iron occurs have been identified in practically all cases, and the clay ironstones are seen to be chamosite and siderite mud stones. It has been found possible to construct a system of classification conveniently divided into two main groups, the ferrous iron ores and the ferric iron ores. The first group contains three sub-divisions, which include the Cleveland ironstone among the chamosite mudstones; the coal measure ironstones or siderite mudstones; and the marlstone or sideritic limestones. The ferric iron ores include the North Wales pisolitic ore, the Frodingham ironstone, a limonite oolite, the primary hematite of South Wales, and, finally, the Glauconitic rocks, of greater scientific than commercial value.

Of the English ironstones, detailed descriptions are given according to this classification. These are necessarily of a very technical character that makes abridgement difficult. From a mineralogical point of view, the chief interest lies in the wide occurrence of the chlorite chamosite, forming the main silicious compound in the clay ironstones.

Of more general interest is the discussion of the manner of deposition, so graphically expressed that it is possible to form a mental picture of the physical and chemical conditions under which the iron ores were formed. The bedded ironstones are aqueous chemical precipitates, so persistent in occurrence and so distinctive in structure, that the theory of metosomatic origin must be abandoned, notwithstanding that in some respects, the ooliths composed of chamosite, siderite or limonite, present a complete analogy with the limestones. This superficial view, however, cannot be maintained, for in no case was a residue found indicating that chamosite ooliths might have consisted of calcite. From whatever side the question is examined, the evidence is entirely against the theory of secondary replacement.

The physical conditions prevailing during the aggregation of the materials can also be traced with some degree of approximation. Current action operated as a factor of deposition, but there were no violent currents, for the ironstones are characterised by the relative absence of even the finest silt or sea-floor mud, hence the waters were not moving with sufficient rapidity to carry detrital material into the ironstone field. No coast line or bar seems essential to the formation of the ironstones, and they might originate on any plane remote from strong current action. But land area or land derived material is necessary for the special content of iron, for the ironstones are characteristically associated with shales and sands rather than with limestones. The reactions that occur during weathering and their bearing on the possibility of secondary enrichment are of special interest and will probably arouse some criticism.

* *Special Report on the Mineral Resources of Great Britain.* Vol. xxix. *Bedded Iron Ores of England and Wales. Photography and Chemistry.* By A. F. Hallimond, M.A., with an Appendix by E. R. Ennos, B.A., B.Sc., and R. Sutcliffe, M.A. London, 1925. H.M. Stationery Office. [Price 3s. net.]

MODERN GRAIN ELEVATORS.

WHEN finely disintegrated particles of carbon such as coal, or hydro-carbons such as flour and sugar, are present in a confined space and in suspension in dry air, conditions very favourable for violent explosion are present. Although employers and employees may, in some industries, work for years without realising even the possibility of accident, the dangers in large undertakings may be very great.

These dangers are prominently brought out in a paper entitled "Recent Advancement in the Construction and Operation of Grain Elevators," read recently before the Montreal branch of the Engineering Institute of Canada, by Mr. L. Coke Hill, Chief Engineer and Director of Messrs. John S. Metcalfe & Co., Limited, Montreal.

In Canada the whole of the grain is treated in bulk only; sacks are never used. Thus the grain, in being moved from one site to another, is in constant motion, and the friction between the grains gives rise to a minutely divided dust which has to be dealt with. Formerly the bins and elevators were constructed of wood, but these have gradually been displaced by steel, while more recently reinforced concrete buildings have been adopted. The latter have been modified, as time has passed, as the result of experience, especially in the direction of introducing as many windows as possible, so that in case of explosion the least resistance may be given to the force of the gases generated. In the earlier wooden structures fires used to occur, and it is suggested that the initial cause of these may have been explosions, but that this fact was lost sight of in the main fire that usually followed, and which usually destroyed

any evidence as to the original cause of the outbreak.

The unloading of railroad cars has progressed rapidly of late from the old hand method which was later followed by the power shovel consisting of a scoop worked by a rope from a drum on the line shaft; but the modern practice is to empty the car by dumping or tilting. This is accomplished in the Metcalf car dumper by running the wagon on to a table about 50 ft. long. The table and wagon are then hoisted about 8 ft. by means of wire cables attached to drums driven by an overhead motor, the outer side being raised more than the inner, giving the wagon a tilt towards the hopper of 14 deg. At the same time the door is rammed open and the grain flows out. The ends of the platform are then raised alternately so that the whole of the 2,000 bushels of a wagon are emptied.

This machine will deal with about seven wagons per hour. In this connection an alternative obviating the necessity of lifting the enormous weight of platform, wagon and contents to the height of 8 ft. as is done in this machine will suggest itself to many engineers. The same effect could be obtained, as far as one can see, by having curved bearer bars on rollers transverse to the track, and a symetrically curved rack driven by a pinion, which would tilt the wagon. The whole dead-weight would then be supported from the floor by the rollers instead of being suspended.

Conveyors have been improved by the introduction of roller bearings, and in general the horse-power required when they are fitted is only two-thirds of that required when plain or ring oiled bearings are used, as the roller bearings are used not only for the rollers supporting the belt, but also for the troughing rollers.

Roller bearings have also been introduced in the elevators, but naturally the power saving is much less in the latter as the load is suspended almost vertically or at a slight inclination only, and the loads on the bearings are small. It would be of interest if data could be given showing the relationship of the higher cost of the bearings, to the decreased cost of the motor and the current consumption over a period of time for installations of this type. The drive to the head of the elevators has been the subject of several recent improvements from the old method of rope drive. In the first place silent chain drives have been adopted, taking up far less room, and in other cases direct coupled motors driving through helical gear have been used. The concrete bins are now constructed with strong reinforced walls between them, the sides or outside panels being provided with ventilators and windows wherever this is possible. The grain is drawn off from the bottom, weighed and elevated to long conveyors, and from them is discharged into either shipping or wagons as may be required. In all these operations dust is created, and cannot be eliminated. The dust settling in the building can be removed by sweeping either daily or periodically, but the disturbance of these deposits immediately raises clouds of dust and supercharges the air. Even when suction sweepers are used, the charge in the pipe is in a highly dangerous state, and it is now recognised that instead of getting everything under one roof, as was aimed at previously, the better and only safe practice is to isolate or segregate the individual operations, open-air spaces being provided between one process and another, so that in the event of explosion the effects are limited. This closely follows the system carried out in coal mining practise, where the mine is not wholly connected but divided into districts, so that an explosion occurring in one district rarely traverses the whole mine, and is confined to a relatively small area.

Mr. Hill suggests, without going into details, that the origin of explosions is usually at the base or boot of the elevator, and it is highly probable that this is the source of many disasters. In the passage of the buckets at high speed up the leg of the elevator, over the top of the drum and over the discharge gear, and down the far side of the leg, no obstruction is met with; but when the bucket reaches the boot it comes in contact with the grain and any foreign particles that may be present, and the sudden load is considerable. Foreign particles such as small pieces of stone introduced with the grain, worn parts of buckets, nuts from the bolts of bucket clips, all fall to the base of the elevator, and a spark may easily be struck under these conditions sufficient to ignite if not to detonate the highly-charged atmosphere in the elevator casing. Mr. Hill points out that wiring for electric lights and motors, by fusing or the breakage of an electric globe, may also be a cause of explosions, but against this it is to be remembered that fires occurred in wooden structures before electricity was introduced. It often happens that in connection with elevators generally much time is spent on the design of the drive, of the head and of discharge shoots, but too little attention is given to the design of the boot where choking occurs, and in case of belt breakage all the trouble accumulates. The boot of an elevator should be always not only readily accessible for inspecting the bearings and clearing out the accumulations of dust, which often set into a hard mass if left for any length of time, but provision should further be made by means of a pit to clear these accumulations away rapidly, the pit being provided with some easy means of removing this debris, so that it may be again quickly available for use.

The safest practice is to make the discharging platforms, together with their hopper, and the lower part of the elevator separate units, while the elevator casing should not extend much above the platform level, the belt and buckets with their contents running in the open, and not enclosed in trunking for a considerable distance before re-entering the elevator casing preparatory to discharge. The conveyors at the top should be well ventilated, and the bins into which the grain is shot should be absolutely isolated one from the other and separately ventilated. The bins themselves have been considerably modified, and only the intermediate walls are strongly built. The general appearance of a modern storage house, with its large window space, is very much like a modern factory. In addition to the means recommended for limiting the effects of an explosion, other means may be adopted of reducing the risks, as, for instance, the addition of more finely divided inert dust when the sweeping up is being done. This dilutes the inflammable dust, and in case of ignition absorbs the heat generated. The principle is, it will be remembered, successfully adopted in mine working.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 22nd inst., at the Institution Building, Storey's-gate, Westminster, the President, Sir Vincent L. Raven, occupying the chair.

TWO-STROKE CYCLE OIL ENGINE.

A paper on "Some Tests on a Two-Stroke Cycle Oil Engine" was presented by Professor E. A. Allcut, M.Sc., of the University of Toronto, Canada. This paper is reprinted, abridged, on page 681 of this issue of ENGINEERING.

Mr. A. E. L. Chorlton, in opening the discussion, remarked that the paper seemed to him rather more concerned with the calorimeter and the instruments used in testing than with the engine itself. Both the author of the paper and the builders of the engine should be congratulated on the unusual mechanical efficiency obtained with the type of single-crank engine tested; this efficiency was 5 per cent. higher than was usual with such two-cycle engines. If there was any inaccuracy in the determination it would arise from the indicator cards. It was difficult enough to take an accurate diagram with a mirror indicator, but even more difficult with any form of pencil indicator. He (the speaker) used the Farnborough indicator for fast-running engines. He thought it advisable that the diagrams should be repeated with another type of indicator, to check the mechanical efficiency. A good deal had been said in the paper about gas analysis. The difficulty here was that different results were recorded nearly every time. Apparently no test was made of the hydrogen content. He would like further observations from the author upon the value of the compression index found in the tests. This was of interest to practical people. Different designers used different indexes, variations being found with various types of engines and with the manner of charging. He asked whether the readings given were regarded as normal for an engine rated at 25 h.p. He had gone through the results to see how they compared with some of the figures obtained in his own tests. He considered the mean pressures to be low. In certain cases the indicated mean effective pressure was 36·7, but he commonly obtained an indicated mean pressure of 42. One engine under test, which had been running some little time, gave the figure of 53; this was one of the highest pressures he knew of for a crank-case compression two-cycle engine. The consumption figures could not be expected to be very good when the indicated mean pressures were low. The consumptions given varied from 0·586 lb. per brake horse-power up to 0·65 lb. per brake horse-power. In the engines he was concerned with the figure was usually quite 10 per cent. less, but in the particular engine he had previously referred to the consumption was 0·45 lb. per brake horse-power. Doubtless if the makers had had the chance of tuning up the engine prior to the tests, better results might have been obtained. The figures should therefore be regarded as representing just ordinary practice. He thought that the engine had been run on gas oil.

Mr. F. H. Livens, Member of Council, remarked that his experience was with four-cycle engines, and it would not do to apply to a small engine like that tested by the author any criticism based on acquaintance with the four-cycle type. The advantage of such small engines was in their simplicity, and, as the author had indicated, accurate tests had not been carried out on this class of engine in the past. The author had stated that the smallest load he could put on was 13 brake horse-power, or just over half the rating, while out of the maximum load he could get, 23 brake horse-power, it was more than half. From that point of view the engine was always running under favourable conditions; further, the oil used was a favourable oil, nothing like so heavy as would be used in this country. The runs were only for 90 minutes, and the engine would have to be a very poor one if it would not run for that period without giving trouble. It would have been interesting if the same method as was used to show the atomising effect on oil for the calorimeter could have been applied to show what happened in the atomising nozzle of the engine itself. It was always very difficult to take indicator diagrams of such engines, and, as Mr. Chorlton had said, 85 per cent. was certainly a high mechanical efficiency.

Captain H. Riall Sankey, C.B., Past President, pointed out that the author had referred to exhaust-gas analyses and had shown that the percentage of carbon accounted for in them was 50 per cent. to 60 per cent. of the total, giving reasons for the disparity. The speaker thought that a similar consideration arose in connection with exhaust temperature. Usually the exhaust temperature was understood to be the temperature in the exhaust at the moment of the opening of the port. That temperature was measured in the marine oil-engine trials, and, by the communications to the discussion, it had been shown that the temperatures obtained by the thermometers were not in any way the temperatures in the exhaust of the engine; indeed, there was a difference of about 250 deg. F. He asked Professor Allcut to say something on the point—whether the temperatures were taken in the exhaust pipe or were the temperatures in the cylinder at the moment of exhaust. Referring to Fig. 16, if, instead of using pressures of a few inches of mercury, they had been those used in solid and air injection, he asked the author what he imagined the diagrams would then be like. On a point not quite germane to the paper, he would say that in their Instructions for Carrying Out Industrial Tests, the Heat Engine Committee intend to say that calorimeter tests, and tests of such a character as analyses of gases, should not be undertaken by the engineer, but should be conducted in a laboratory by a specialist. In the early reports of the Thermal Efficiency Committees, the lower calorific values of fuels had been

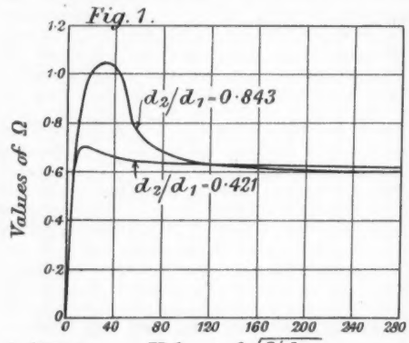
taken as the values on which thermal efficiencies had to be calculated. The new Committee had quite unanimously adopted the higher calorific value, and it was possible that some engine makers might object, since the efficiency would come out lower—say 2 per cent. It might be argued that the engine, no matter what type of internal-combustion engine it might be, was unable to use the latent heat of the condensed steam. That was a legitimate argument. He would like to know what Professor Allcut's views on this point were. He noticed that the engine had a hot top to it, and was therefore working on the cycle patented by Ackroyd Stuart in 1890. Sometimes it was called a "Semi-Diesel," a term the use of which the Institution hoped to suppress.

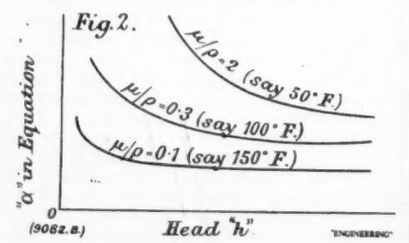
Captain King, of the Air Ministry Research Staff, referred to the calorimeter. When dealing with the Junker calorimeter with the primus burner and oil tank, carried on a balance in such a way that the rate at which the oil was burned could be readily recorded, he had found a method to deal with heavy oils. Even the heaviest oils could be tested by employing a half and half mixture of the oil with petrol.

Mr. John L. Hodgson discussed the use of orifices for measuring oil flows. His own work on square-edged orifices placed between two flanges in a pipe line and bevelled off on the down-stream side, and with the pressure holes in the plane of the orifice, had shown that the value of the coefficient of discharge, Ω, in the equation

$$G = \Omega \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{\frac{2h}{\rho}}.$$

was given for large and small values of the ratio d_2/d_1 by the curve shown in Fig. 1. In this expression G = discharge in grammes per second, a_1 = area of pipe-line up-stream and down-stream of the orifice in square centimetres, a_2 = area of





orifice in square centimetres, d_1 and d_2 = corresponding diameters in centimetres, h = difference of pressure across the orifice in dynes per square centimetre, ρ = density of fluid passing in grammes per second.

It would be seen on reference to Fig. 1 that when the coefficient of discharge Ω was plotted against the square root of the Reynold's criterion, $G/d_2\mu$ (where μ is the viscosity of the fluid in C.G.S. units), the coefficient curve was a straight line parallel to the "X" axis in the turbulent region, and a straight line passing through the origin in the viscous region. Further the flow was quite definitely turbulent for values of the square root of the Reynold's criterion which were greater than 200, and definitely viscous for values below 5. Having obtained such curves as those shown in Fig. 1 for the particular proportions and situation of the orifice used, it was possible to plot curves similar to those shown in Fig. 2 which connected values of $a = \Omega \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2}$, and the various values of the kinematic viscosity μ/ρ. Alternatively, since the kinematic viscosity varied with the temperature, these curves might be plotted to correspond to various temperatures. It was interesting to note that if the curve connecting temperature and kinematic viscosity was plotted on a logarithmic basis it would usually be found to be a straight line. Curves such as those shown in Fig. 2 having been drawn out, it was only necessary in any actual test to observe the temperature of the oil and the "orifice head" in order to determine the rate of discharge, as a knowledge of the temperature enabled the kinematic viscosity to be determined and the correct curve in Fig. 2 to be used, and a knowledge of the "orifice head" enabled the correct value of a in the equation $G = a\sqrt{h/\rho}$ to be read off. An alternative method was to plot in place of the group of curves shown in Fig. 2 a single curve connecting a and $h/\left(\frac{\mu}{\rho}\right)^2$. Further, if the temperature range was so small that the density of the oil could be assumed constant, the discharge could be obtained from curves which were drawn for various temperatures and which connected "head" and "discharge." It would therefore be seen that an orifice-meter in which an automatic correction was made which depended upon kinematic viscosity (or more approximately on temperature alone) would measure the rate of discharge of viscous fluids with accuracy.

Mr. A. L. Bird intimated that at Cambridge University they had an exactly similar engine, with which certain experiments had been carried out on specific points, namely, gas analysis and the temperature of the hot bulb. For the gas analysis a sampling valve was fitted to the cylinder through the indicator hole, which could be actuated at any time as required. It was hoped that in that way it would be possible to get the scavenging characteristics of the engine by taking samples on the compression and the firing strokes and comparing the results with the exhaust pipe analysis. The results were satisfactory for the firing stroke. At a load of about 17½ h.p. the firing stroke gave 4·7 per cent. CO_2, compared with 4 per cent. in the exhaust pipe. This allowed for some of the scavenging air going through. Professor Allcut obtained something like 80 per cent. volumetric efficiency, whereas the speaker's engine gave only 50 per cent. Referring to the point made by Mr. Livens in connection with the load, the speaker said that to his engine a Heenan and Froude brake had been applied, so that it was possible to run on any load desired. He had hoped to get some information on the effect of the governing device, which consisted of an arrangement for advancing the injection as the load decreased. From full load to no load, the temperature ranged from 700 deg. C. down to 400 deg. C. Professor Allcut's diagram, Test "A" (2), Fig. 2 of the paper, showed an undesirable form. He had been trying experiments with fine jets. A travelling microscope was used to determine the size of the orifice, which could be made of any shape. Using such an orifice and a pressure of 2,000 lb. per square inch, a simple injection was made and the plate was covered with drops which it was possible to count. In one particular case they spread out over a length of about 4 ft., and on counting them at intervals a curve could be obtained showing the distribution over the 4 ft. Integration of the curve of their number plotted against distance along the plate would give the number of drops as about 17,500, giving also the average size of drop as about 0·005 in. diameter. Both these results and Professor Allcut's confirmed a long-established suspicion that the size of the drop in atomisation varied considerably.

Mr. C. J. Taffs referred to the curve of mechanical efficiency in Fig. 6 of the paper, which, as drawn, was straight. He suggested that it should take the usual curved form. In the same figure the oil per brake horse-power hour and the oil per indicated horse-power hour were shown at minimum values at 17-18 h.p. It was usual in these engines to find that the minimum rate of fuel consumption was reached after the engine rating was passed. The carbon dioxide figures were very low. In mentioning exhaust gas temperatures, Captain Sankey had not stated that his reference related to the First Report of the Committee, and that the engine worked on the 4-stroke cycle.

Mr. R. W. Allen, C.B.E., Vice-President, thought that for the purposes of intelligent discussion the results obtained in Toronto should be compared with those secured at home. In fact, the speaker hardly thought it justifiable to institute a comparison of the merits of the two-cycle and other engines. The Professor had put before the Institution the facts as he found them, and the speaker did not think it necessary to discuss the actual design. Mr. Taffs had raised a point which interested him, namely, the oil per brake horse-power per hour. He would ask Professor Allcut whether he was satisfied that the tests were right in that regard. The consumption recorded was at about 20 h.p., and, as Mr. Taffs had said, the best consumption of fuel per brake horse-power was at the maximum horse-power of the engine. He was a little surprised, therefore, to see the curve turn upwards towards the maximum power.

Mr. John L. Challoner observed that he could not agree with Mr. Allen that the best fuel consumption was found at maximum horse-power. In fact, in a large number of tests which he had either carried out or inspected, he had found the best fuel economy was obtained at somewhere about 0·8 to 0·85 of the normal power rating. In his research work Professor Allcut only carried the power to 22-23 b.h.p.; the difference between 23 and 25 was about the percentage allowed usually by manufacturers between the normal and maximum rating of an engine. He therefore wondered whether Professor Allcut had taken the normal rating as the limit for experiment. Mr. Livens urged that it was the fault of the engine that small loads could not be used, but Professor Allcut said it was the fault of the brake, and he thought that the Professor was right. In a very interesting paper, Dr. Mellanby had drawn some conclusions in reference to the mean indicated pressure as related to oxygen content, and had found a law connecting the two. He had borne that out by actual experiments carried out on a similar engine. Taking the figures given by Professor Allcut, the speaker had roughly compared the mean indicated pressure and oxygen content, and had found, by extrapolation, that the base line was cut somewhere about 95 lb. Dr. Mellanby said that the maximum mean indicated pressure to be anticipated was somewhere in the neighbourhood of 140 lb. He asked Professor Allcut, assuming that the relation between the oxygen content and mean effective pressure was established, and assuming the Professor's exhaust analysis figures to be correct, whether he would be prepared to draw any conclusion between that relative figure of 140 for the four-stroke engine and his own figure—which he might wish to check—of 95. Manufacturers of heavy oil engines were inclined to say that the engines could use a very wide range of fuels. In carrying out these experiments and analysing the figures and comparing the fuel consumption, it should be kept in mind that a high grade of fuel was used, with a comparatively low fuel consumption. In some work on atomisation, a relation was found between the size of the globules of oil and the air pressure. The sizes of globules varied from 1·3 to 0·62 μ, where μ was 0·001 mm. In analysing the difference in calorific values, obtained in the experiments with the Mahler bomb and Parr calorimeters and the author's calorimeter, this difference appeared to be less than 1 per cent., and with such a percentage of accuracy the particular calorimeter used scarcely mattered.

Mr. W. H. Patchell, Past-President, referred to the fact that Professor Allcut had started his association with the Institution as a Graduate. He had wished to hear more about the question of calorific value of the fuel, mentioned by Captain Sankey. When the Americans were over here last year, it was decided unanimously to go for the higher or gross value for boiler work, and the only

question left open was whether to go for the higher value for gas and oil or to stick to the lower. It was well known that in Great Britain gas was sold by the higher calorific value, by Act of Parliament. He had recently expressed the hope that, as the lower value had only been abandoned because it was a more difficult value to get, the demand for the best—or lower—value would develop some ready means of getting it.

Captain H. Riall Sankey, speaking a second time, called attention to the results shown in Fig. 6 of the paper, and suggested that it was his own practice to plot total oils, measuring what was actually got and drawing the best straight line possible through the observed points. From that straight line, which had been drawn to eliminate experimental errors, could be deduced the oil per brake horse-power, without showing any experimental points at all. He had roughly plotted the figures, and found the line was not straight, one point being distinctly outside it, and this would be better omitted.

Professor E. A. Allcut then replied to the discussion. The object of the tests was to find what happened in a two-stroke cycle oil engine, and, as he had pointed out, few records of comprehensive tests, which gave the desired information, were available. He had set to work to procure that information, and having done so, whether the results were good or bad, he had presented them for consideration. He recognised at the time the tests were made, that the mechanical efficiency was high in comparison with published results. Since the paper was written, the tests had been repeated by students and others, and their results, both in respect to fuel consumption and mechanical efficiency were very close to the results given in the paper. Mr. Chorlton asked for more information as to the value of n so far as it concerned the compression curve. The usual figure for n was 1·35 or thereabouts, and in the tests he got the value of n both from the light-spring cards, shown in Fig. 4 and from the heavy-spring cards, the average being $n = 1{\cdot}334$, which was close to the usual figure. The consumption curve had been checked up, and did show a minimum value at about 18-h.p. Viscosities at various temperatures, obtained with the Saybolt viscometer, were given in the paper. Mr. Livens had referred to the time of test. The speaker stated that the 90 minutes was the actual time during which the observations were taken, and was not the period during which the engine was running. It was obvious that the consideration influencing the exhaust analyses, would also influence the exhaust temperatures. For that reason—although the exhaust temperatures were, he might say, taken within 4 in. of the exhaust slots which was pretty close to the engine—the figure was only a mean for the exhaust temperature, just as the analysis was only a mean for the analyses. With regard to the water of condensation, he had been for years a consistent advocate of the use of the higher calorific value, and he was still unrepentant. On the whole, he felt that there was a decided move towards the use of the higher calorific value for all fuel, and he thought that there was an irresistible case, from a technical standpoint at any rate, in favour of it; whatever might be the practical advantages of the use of the lower calorific value. To obtain directly the lower calorific value in the case of the calorimeter he used, there was the difficulty—which might be overcome—that the water of condensation that was collected was not the total amount of water produced by the combustion of the fuel, for the reason that the air, when it entered the calorimeter, was only partially saturated, whereas, on coming out, it was in all probability saturated. He had been much interested in Captain King's remarks about the use of the 50 mixture of oil and petrol in connection with the heavy oils. In the new form of calorimeter, arrangements had been made for preheating the heavy oils, so that he had hopes of using the oils themselves without such a mixture; this method had not yet been tried.

The President, in proposing a vote of thanks to Mr. Allcut for his paper, said he felt that the Institution was much indebted to Professor Allcut for coming to the meeting and giving them the results of his investigations.

Professor Allcut returned thanks for the vote which was passed by acclamation, and remarked that he quite appreciated the frank discussion they had had. The announcement was then made that the next meeting would take place at Newcastle-on-Tyne in connection with the Summer Meetings, on July 6 to 11 next.

NOTES.

Electricity at Shanghai.

From the Manager's report to the Electricity Committee of the Shanghai Municipality it appears that, in spite of acute trade depression and inter-provincial warfare in the very neighbourhood of the city, the sales of electricity have continued to increase, and reached for the past year 307,307,401 kw.-hours, as compared with 272,265,861 units in the preceding twelve months. This result is extraordinary when it is remembered that in 1924 the sales of the Manchester municipal power station amounted only to 222,203,023 units. The load factor of the Shanghai station is also remarkable, being no less than 55·12 per cent.; that at Manchester is 30·79 per cent. The gross revenue amounted to 1,384,650*l.*, and the nett profit, after provision for loans and other charges, was 219,624*l.* The total capital outlay has been 4,571,449*l.* The installed plant has a rated capacity of 121,000 kw., inclusive of the 20,000 kw. unit now being supplied by Messrs. Parsons, in substitution for that destroyed in so extraordinary a way in 1923. The average overall thermal efficiency of the station was 16·2 per cent., as compared with 14¼ per cent. in the preceding year. A kw.-hour was obtained for an average expenditure of 21,047 B.Th.U., but the best figure noted during the twelvemonth was 19,271 B.Th.U. per kw.-hour. It is anticipated that still better results will be recorded in the next report.

Relativity.

In a letter published in *Nature* for May 23 last, Professor L. Silberstein gives particulars of a repetition at a high level of the famous Michelson-Morley experiment. The object of this experiment was to determine the speed with which the earth moved through the ether, and the negative result recorded led ultimately to the doctrine of relativity, the more ardent exponents of which declared they had no need for an ether, and were inclined to deny its existence. The Michelson-Morley experiment was made at a low level, and the possibility that the ether might in this region be dragged along with the earth was never excluded, although such an assumption involved certain other difficulties, and it was accordingly decided to repeat the experiment at a high level. This work has now been completed by Professor D. C. Miller, who, after a number of preliminary experiments, proceeded to Mount Wilson, and in the course of observations which have extended over four years has obtained a positive result, the relative speed of the earth and the ether at this level being found to be 10 km. per second, which is about one-third of the theoretical value due to the motion of the earth in its orbit. This positive result will no doubt be the subject of confirmatory experiments by others, but if definitely established it will, to quote Professor Silberstein, "Knock out the relativity theory radically." It may be added, that a few weeks ago Professor Michelson described an experiment in which the rotation of the earth relatively to the ether appeared to be established, and on this we commented at the time.

William Sturgeon and the Centenary of the Electromagnet.

In July, 1820, Professor Oersted observed accidentally, in Copenhagen, that the electric current deflected a magnetic needle; he described the experiment in a Latin treatise. Arago and Ampère made similar experiments in Paris in the same year, and Ampère explained the directions of the electric and magnetic forces in his "Phénomènes Electrodynamiques." Other famous men worked on similar lines; but it only occurred to William Sturgeon, the self-taught shoemaker and once private soldier in the Royal Artillery, to twist the bare copper wire from a battery round a horse-shoe, or bar, of soft iron. For his paper on this invention of the electromagnet of May, 1825, the Society of Arts granted Sturgeon a medal and a premium of 30*l.* Outlining the development of the study of electromagnetism with special regard to magnetic alloys, at the Royal Society of Arts on the 20th inst., Professor J. A. Fleming mentioned that Sturgeon, after leaving the Army and Woolwich, became Superintendent of the Victoria Gallery of Science in Manchester in 1838, and started the "Annals of Electricity." But he was overshadowed by other great men: the Victoria Institute failed, and Sturgeon lived in penury, until Joule and other friends procured him a grant from the Civil List and a pension of 50*l.*, which he did not live long to enjoy. He died in 1850 at Prestwich. His researches were published in a heavy quarto volume, a copy of which Mr. W. M. Mordey showed at the meeting, drawing attention, with other speakers—among whom were Colonel Crompton, Mr. R. Appleyard, and Mr. A. Campbell Swinton, the chairman—to the diversity of Sturgeon's work. The early electromagnet had but little power unless mounted close to the battery, the phenomenon of electric resistance not being understood until Ohm deduced his law in 1827. Then a search was made for magnetic materials. Iron, it had been found, lost its ferromagnetism at about 780 deg., cobalt near 1,090 deg., and nickel at 360 deg. cent. Hadfield's alloy (Fe 88, Mn 12), and the Dawson-Ferranti alloy (Fe 81, Mn 6, Ni 9), were practically non-magnetic; Heusler's alloy (Mn 22·4, Cu 60·5, Al 11·6) was ferromagnetic, although free from iron, whilst some other copper-manganese alloys became magnetic on addition of a third constituent. Hopkinson's alloy (Fe 75, Ni 25) was non-magnetic unless cooled below zero, but then remained magnetic up to 580 deg., and could exist, at ordinary temperatures, in two different magnetic states. Permalloy (Ni 78·5, Fe 21·5) had an enormous permeability, but only in very weak magnetic fields, and had proved valuable for the loading of cables. The real nature of magnetism was little better understood now than in Sturgeon's days. Professor Fleming adopted the suggestion that iron existed in two allotropic states, physically very different—the ordinary magnetic α-iron and the non-magnetic γ-iron; the change into γ at 800 deg. was catalytically facilitated by the presence of manganese. Ferromagnetism seemed to be associated with a body- (not face-) centred lattice; the α-iron, according to W. H. Bragg had, in the lattice eight near neighbours, γ-iron 12, and the latter had therefore less elbow-room. The element which underwent orientation in magnets was not Weber's molecule, but, according to Ewing, the orbit of the outer electron, and Professor Fleming showed how the loss or gain of electrons would change the polarity and forces between the iron ions in the lattice.

Contracts.—Messrs. John Thompson Water-Tube Boilers, Limited, of Imperial House, Kingsway, London, W.C.2, have secured an order from the York Corporation for two vertical boilers, each capable of evaporating 25,000 lb. of water per hour.—Messrs. Guest and Chrimes, Limited, of Rotherham, will supply the valves and iron-work for the Broomhead Reservoir valve shaft of the Ewden Valley Waterworks, being constructed for the Sheffield Corporation.—The D.P. Battery Company, Limited, of Bakewell, Derbyshire, have provided batteries of their Kathanode locomotive tyre for use on the six standard gauge locomotives being constructed for the War Office and Air Ministry by the English Electric Company, of Rugby, Messrs. Hawthorne, Leslie and Company, Limited, of Newcastle-on-Tyne, and Messrs. Joseph Booth Bros., Limited, of Rodley, Leeds.—Extensive orders have been placed with the Metropolitan-Vickers Electric Company, Limited, of Manchester, for sub-stations and other electrical equipment in connection with power transmission schemes designed to link up important South African mining areas. The steelwork employed will be manufactured and erected by Messrs. Heenan and Froude, Limited, of Worcester.—An order has been secured by Messrs. Howden Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, for the supply of one preheater to Messrs. Brown and Adam, Limited, dyers and bleachers, Riverbank Works, Pollokshaws, Glasgow.—Messrs. Vickers, Limited, of Vickers House, Broadway, London, S.W.1, have obtained a contract from the Australian Government for two submarines.—The London Midland and Scottish Railway Company have placed contracts for a brick and steel bridge to span the River Brent, near Wembley, with the Butterley Company, Limited, of Derby, and Mr. Thomas Higgs, of Northampton.

LETTERS TO THE EDITOR.

THE FINENESS OF PORTLAND CEMENT.

TO THE EDITOR OF ENGINEERING.

SIR,—Your leading article, in a recent issue of ENGINEERING, on the fineness of Portland cement leaves one with an impression that both manufacturers and consumers require "something" from Portland cement which they have so far failed to obtain, as is shown by the wish to return from the sieve test to the flourometer test, once strongly pressed for by the consumers. May not this be expressed in the question, What is cement flour? It would appear from the tests quoted in your article, that flour, though influenced by fine grinding, may not actually be the finest particles only, but that there are, in addition, other properties in flour, the chief of which is its solubility, and this I suggest may be connected with the character of the particle.

In the manufacture of cement other changes have taken place besides that from chamber kilns to rotary kilns, an important one being the change in grinding machines from the old flat burr stone mill to the tube mill. The action between the two is entirely different; in the old mill the material was rubbed to a powder and one would expect to find it of a flake-like appearance, while in the tube mill it is really broken up by innumerable blows, and an appearance of many individual polyhedrous grains might be expected. The latter supposition is supported by the results of experiments recently carried out by the British Portland Cement Research Association on the fine grinding of Leighton Buzzard sand, which is of a crystalline nature.

Of the two tests for cement, the sieve test is obviously the least useful, as in passing through the sieve only two of the dimensions of the particles are known for certain, these being the length and breadth. But the depth might be anything in reason; for instance, if a long fine wire or hair were passed through the mesh of the sieve it would not be called a fine particle. The flourometer is surely the more accurate test, as, in addition to two dimensions of area exposed to the air blast, a third factor—namely, the question of weight—is also introduced, and it is reasonable to suppose that a flake or particle with length and breadth but of infinitesimal depth, would be more soluble than a particle half the length and breadth, but four times the thickness. That these spherical particles are not soluble, though they may be rendered so by further reduction, is fully demonstrated in the test quoted in your article, and it may be of interest to indicate the two sources from which these insoluble particles may originate, namely, in the calcining or in the grinding.

When cement is calcined, it is fluxed into small pellets called clinker; if one of these pellets be broken open the appearance of the centre will often differ from that at the edge, and, in general, the calcining is governed by the appearance of the resulting clinker. The point to consider is whether the structure of the pellet is uniform, or whether the outside shell is crystalline and the centre stratified, and, in the latter case, the relative proportion of one to the other, though of the same chemical composition. In the subsequent grinding, it may be expected that one would have a different fracture or line of cleavage to the other, and the outside shell would be reduced in the shape of spheres, while the stratified part would be of a more flake-like character, and of a more soluble form. This could possibly be observed by the use of a powerful microscope, for though the eye can detect differences in the appearance of the clinker, it cannot detect differences in the ground cement without some such aid. In the test quoted in your article, it would have been of interest to know what was the appearance of the residue left in the water; whether it was composed of small crystalline pieces, and what it appeared like after being ground in a pestle and mortar. It may here be noted that in the second grinding, rubbing action was introduced in place of the previous impactive grinding. If the action of flints on the seashore be considered, it is known that they break up other stones and each other, and, as a result, sand and exceedingly fine sand are produced, but never mud or clay. In the potteries, though a few dry and wet ball mills are used, the majority of manufacturers still stick to the old wet rubbing method, with its many expenses and difficulties of pumping and drying, as they contend that it works better and smoother with the clays that are afterwards introduced. I believe I am correct in saying that an expert can tell by the feel of ground flint whether it has been ground by pebbles in a tube mill, or by the rubbing of chert stones, though both resulting products will pass the same sieve test. The tube mill will handle large quantities of material and rapidly reduce it to a certain fineness, after which further reduction is very slow, so that, however often the material be passed through the mill, very little further reduction takes place; in practice it is known that the efficiency of the tube mill is limited. On the other hand, the burr-stone mill will only handle small quantities, and is more expensive to run, both in power and upkeep; but a combination of the two working methods might be devised with beneficial results, such as passing the material through the tube mill, followed by slight air separation, the heavier residue being finished off in a mill with a rubbing action such as a Griffin mill.

Yours faithfully,
J. CARR-ARCHER.

48, Borough High-street, London, S.E.1.

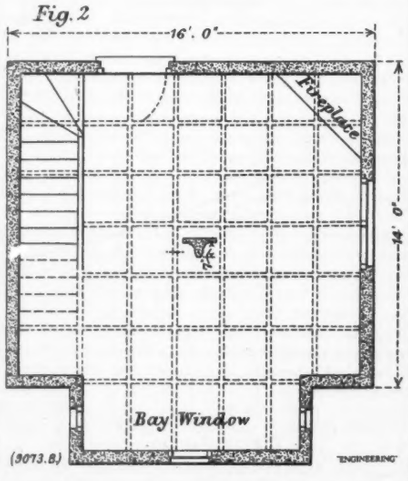
THE INVENTOR OF REINFORCED CONCRETE.

TO THE EDITOR OF ENGINEERING.

SIR,—To those curious about the beginnings of things, it will be of interest to give some account of one but little known, though well worthy of remembrance. W. B. Wilkinson, of Newcastle-on-Tyne, was, getting on for a century since, actively engaged in the building industry, more particularly in relation

FIG. 1.

Fig. 2



to moulded or pre-cast items to be used in place of stone, brick, or cast-iron. He was one of the earliest users of Portland cement, appreciating its qualities. In 1854 he was granted a patent (No. 2293), for a method of fireproof construction, which, on examination, proves to be nothing less than reinforced concrete. In this material he carried out works of construction, and—the work done in France not being overlooked—was probably the first exponent of this particular form of building construction.

There still stands in Northumberland-road, Newcastle-on-Tyne, a cottage of 16 ft. by 14 ft., built by him about 1865. This little house, after 60 years, is still in good order. It has one large room on the ground floor, with a panelled ceiling having deep ribs (Fig. 2); from this room rises a staircase of concrete, cast in place, to the floor above. Mr. Steel, the city engineer, writes: "Generally the work appears to be in fairly good condition, and shows no sign of general disintegration, such as would have occurred in the event of the embedded iron expanding due to oxidation." The business of Wilkinson was later taken over by the present Mr. W. Ferguson, who claims 60 years' experience of Portland cement, and who confirms Mr. Steel's statement. The one defect in this building, visible in Fig. 1, is above the bay-window where, the reinforcement being too near the surface, the cover has come away. Other work was also carried out by Wilkinson, at about the date indicated, or a little later, including house construction, stable with flat roof, reinforced paving—taken up about 30 years since—and a floor of 14 ft. span to carry a baker's oven.

Having regard to the nature of Wilkinson's activity in this direction, it is not too much to claim that he was the inventor of reinforced concrete as applied to serious construction, as distinct from cement on wire mesh for light articles first developed in France.

Yours faithfully,
W. H. THORPE.

12, Buckingham-street, Strand, London.
May 15, 1925.

THE ACCIDENT TO THE R.33.

TO THE EDITOR OF ENGINEERING.

SIR,—I am glad to see that, in his letter in your last issue, Major Teed adopts the suggestion I made in the course of the discussion on Commander Burney's paper at the Institute of Transport Congress, that the Government's Airship Co-ordinating Committee is the appropriate body to adjudicate on the relative merits of the two methods of airship mooring. In concluding—so far as I am concerned—this correspondence, perhaps you will permit me to point out that it was Major Teed who started it, and the Airship Guarantee Company, who have appealed to the public through the press to form an opinion on a technical matter which is best left for decision to the judgment of the impartial committee appointed by the Government to advise them on such matters.

Yours faithfully,
W. LOCKWOOD MARSH, Lieut.-Col.

Hockering Gate, Woking, Surrey.
May 23, 1925.

WATERLOO BRIDGE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I refer briefly to two points in your note of May 22 on this subject? The London County Council proposes to demolish Waterloo Bridge because they say it cannot be repaired, and as it must, therefore, be pulled down it would be better to erect an entirely new and much wider bridge. With the first contention you disagree, but to the second you subscribe. The large number of town-planning and traffic experts, who are either members of this club or of the societies allied with it on this matter, hold that it is fatuous to make bridges wider without providing adequate approaches and considering the traffic lines to those approaches; and that, so far from being an assistance to the traffic facilities of London, the proposed wider bridge at this point would only add to the already intolerable congestion in the Strand. Further, that the right policy is, therefore, not to tempt traffic to a point where the traffic lines and approaches cannot be suitably arranged, but to provide another crossing at a point where the district can be adequately served and where it is urgently needed.

The vaunted tunnel under the Strand, with its terribly steep gradients, need only be mentioned to be dismissed. The L.C.C. do not pretend that it will even take the present cross traffic, let alone the increase that will be lured to the spot by the promise of increased facilities.

Expert engineering advice which has been obtained sees no difficulty in repairing the present structure at a fraction of the cost of the proposed new structure, and, in these circumstances, the severely practical course appears to be to repair the present bridge for the mid-Strand traffic, which it is quite adequate to deal with, and provide a new bridge and approaches where they are urgently needed. You would thus have two bridges giving good service, instead of one that will merely add to the present traffic difficulties.

If the question was merely one of æsthetics against

the pressing traffic necessities of London, then my Committee would not be found opposing the destruction of the present bridge, much as they would regret its disappearance. At the same time, your assertion that the bridge impedes the river traffic is a point that demands attention. It is an old story and one that will lose most of its point when the development of the south bank of the river sweeps away the existing ugly range of wharfs and warehouses. Few will be found to agree that one of the finest bridges in the world should be demolished, however, merely to perpetuate the present archaic system of lighterage.

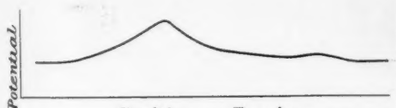
I am, Sir, your obedient Servant,
J. H. ELDER-DUNCAN, Secretary.

The Architecture Club, *The London Mercury Office*,
Castle Court, Poppins Court, London, E.C.4.
May 25, 1925.

THE DETECTION OF FLAWS IN METAL MASSES.

DURING recent years, a considerable amount of attention has been given to the development of methods for the detection of flaws in metals. The advent of X-rays was considered to point to a speedy solution of the problem, but that method has not been so successful as was anticipated. X-rays are certainly very useful when dealing with small thin articles and can be used up to a thickness of about 4 in., but the method is then lengthy and cumbersome, and requires much skill and experience correctly to interpret the observations.

Messrs. C. W. Burrows and F. P. Fahy, of the Bureau of Standards, Washington, and others, have devised methods of magnetic analysis of steels which indicate not only the character of the steel but lack of homogeneity due to any cause whatever. Such methods naturally indicate the presence of flaws, and certain American railroads are using them for the routine testing of rails. An account of this work is given in the volume of "Technical Papers" issued in connection with the 1919 annual meeting of the American Society of Testing Materials. The method is very useful for sections up to and including railway rails, and, for this particular case, it is rapid and easy, no previous preparation of the rails of any kind being



Position on Forging.

required. When, however, large sections have to be dealt with, the method is not sufficiently sensitive.

In connection with the manufacture of rotors for turbo-alternators, Messrs. Bartlett, Rossignol and Wilson of the Research and Development staffs of the General Electric Company, Limited, of Magnet House, Kingsway, London, and Witton, Birmingham, set out to devise a satisfactory routine method of testing rotor forgings up to at least 50 tons in weight, and also for testing the rings used for retaining the overhang of the windings. As the magnetic method had proved successful with small sections, it was the first to be tried, and was carried out in a number of ways, but without any measure of success. It was necessary, therefore, to search in other directions, and after a survey of possible methods it was decided to experiment with a drop of electric potential method. This has given results which are believed to be far in advance of those obtained by any other method. The method is a very simple one, but requires a great amount of care and a number of precautions to arrive at the truth when employed on a large rotor forging. A fairly large direct current is passed through the rotor from end to end and an insulating block, with two steel points rigidly fixed a certain distance apart and connected to a sensitive galvanometer, is applied step by step along the whole rotor length, and the deflections noted. In a rotor, difficulties are introduced by the change of section, so that when the results are plotted the curve is not a horizontal line but a series of horizontal lines or steps of various lengths connected by more or less smooth curves. In actual practice, flaws have been detected and rotors have been scrapped which, had they been put into service, would undoubtedly have failed when run, probably with most disastrous results. The accompanying figure shows a portion of the curve obtained on the body of one of these faulty rotors (22 in. in diameter) which was afterwards cut up. Immediately under the centre line of each of the two humps were found clinks, one of 16 in. diameter and the other of 9 in. diameter. In addition, some small flaws near the surface were also indicated and afterwards found.

Similar tests were also carried out on the retaining rings already mentioned, the current being led in and out at opposite ends of a diameter. In order to test the complete ring, it is necessary to take a second set of observations, the current being led in and out at another diameter. It should be understood that flaws running parallel to the direction of the current flow would not usually cause any appreciable variation in the potential drop.

The publication of these results has been hastened by the issue of Sir John Pringle's report on the Lytham railway accident, in which the disaster is said to have been caused by the failure of an engine tyre due to a flaw. In this report is reproduced a photograph showing the section containing the flaw. Colonel Sir John Pringle, at the end of this report, states: "The existence of the cavity could not, with present-day appliances, have been detected during the manufacture and subsequent turning, as there was no evidence of the extension of the cavity to, or of hair cracks in, the surface." And, again, he suggests to the railway companies generally the desirability of "devising, with the aid of research departments, some practical means whereby flaws in metal used for tyres, axles, &c., can be detected."

The photograph of the fracture has been carefully examined, and the authors of the experimental work referred to above, are confident that the flaw shown would have been detected had it been tested by the method described, probably even when the tyre was on the hub, and the method is offered to those concerned as one which might be tried out for this type of article. The method is, of course, also applicable to non-ferrous metals and alloys.

LABOUR NOTES.

IN his presidential address to the National Committee of the Amalgamated Engineering Union at Southport on Tuesday, Mr. J. T. Brownlie alluded to the proposals regarding working hours and wages which have been made by the Engineering and Allied Employers National Federation. To have made a complete reply to the offer, or to have issued a manifesto on the subject—as they were asked to do by one or two districts—in the opinion of the executive council, would have been, he said, a tactical blunder. There was not the slightest doubt, however, about the determination of the A.E.U. executive, and of all the other executives interested, to resist the extension of the working week. If they had correctly interpreted the action of the employers, well and good; if not, they would have to face the situation as men. He hoped that they would find ways and means of getting out of the difficulty without extending the present working day, which was the only thing the workers had got out of the war.

Exactly what the National Committee decided to do, in the private meetings which followed Mr. Brownlie's opening address, is, at the time of writing, unknown outside official circles. But if the delegates shared the President's hope that ways and means would be found of getting out of the difficulty without extending the present working day, it cannot correctly be said that the leaders of the men have any clear conception of the issue. In later conferences, the representatives of the unions pressed the employers to indicate the relaxations of working conditions which would, in the opinion of the employers, enable the industry to yield higher earnings to the workers. In their proposals—which the unions, in effect, decline to discuss in conference, or in a complete reply, or in a manifesto—the employers clearly give the required indication. The offer is sincere and not, as is apparently assumed, tactical, and it calls for straightforward treatment at the hands of the unions. If Mr. Brownlie, and those who are acting with him, know of ways and means of getting the industry out of its present troubles without extending working hours, their plain duty to their constituents is to indicate them. The most important fact of the matter from every point of view is that, owing to its high production costs, the industry is becoming less and less able to compete with foreign industries working longer hours, paying lower wages and operating under much more favourable conditions. If the unions know of any other way than that which the employers have proposed of off-setting these economic advantages of the foreigner they are keeping themselves in a bad, and not a good, tactical position by refraining from mentioning it.

Dealing with domestic affairs of the union, Mr. Brownlie said that they had to admit that they had lost members during the past twelve months; but, on the other hand, they had over 8,500 fewer members unemployed. A year ago their percentage of unemployment was 10·22; to-day it was 6·61. Since July, 1920, they had paid approximately six million pounds in benefits—a record not possessed by any other similar organisation in the world. He ventured to say that, but for the fact that they had lost 200,000 members since 1920, the engineering employers would not have dared to put forward the proposals they had made. As for the men who had left their ranks from mercenary motives and unjustifiable reasons, on their consciences rested the responsibility for what had happened.

The Ministry of Labour states that, on May 18, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,185,000—912,800 men, 34,200 boys, 207,500 women, and 30,500 girls. On May 11, 1925, the number was 1,184,251—905,798 men, 36,233 boys, 209,608 women, and 32,612 girls—and on May 19, 1924, it was 1,021,032—757,635 men, 34,620 boys, 195,456 women, and 33,321 girls.

The fourth annual report of the Director of the International Labour Office, issued by the International Labour Office, Geneva, contains a section dealing with conditions in Russia. It is stated that industrial production is only 42 per cent. of what it was before the war. In the metal industry, it is not more than 26 per cent., in the mining of iron ore 10 per cent., in the cotton industry 39 per cent., in the timber industry 35 per cent., and so on. The number of unemployed is 1½ million, and is still increasing. The workers' output is considerably less than it was before the war. The cost of labour is excessive, and this constitutes a heavy burden on industry, which is under-capitalised. The basic capital of industry is exhausted, technical equipment, plant, and all the means of production are outworn and obsolescent. The question of capital and the question of markets are the two fundamental problems with which, according to all Russian economic writings and all the declarations of the Soviet leaders, present-day Russia is faced.

The trouble over the rates of wages to be paid and the working conditions to be observed in the construction of steel houses has reached a critical stage in Scotland. The District Committee for the Middle Ward of Lanarkshire recently ordered 100 Weir houses, and the Mid-Lanark District of the Building Trade Operatives' Federation have called a strike for Monday on the local authority's other housing enterprises, on the ground that Messrs. Weir do not recognise building-trade wages and conditions of employment. The decision of the building-trade operatives is to be considered at a meeting of the Middle Ward District Committee to-day, and locally the hope is that they will adhere to their contract with Messrs. Weir. There is no justification for the interference of the Federation. Steel houses are not buildings in the accepted sense of the term; therefore, building-trade conditions do not properly apply. Moreover, the production and assembly of their parts are legitimately the work of men who are not building-trade operatives and whose wages and conditions are determined by negotiations with which the building trade unions have nothing to do. Finally, they represent an emergency measure which the community believes will appreciably relieve the present shortage of houses, and the community is, after all, the final arbiter in all matters of this kind.

Speaking, on Monday, at the International Labour Conference at Geneva, Mr. Betterton, the British delegate, said that, while the British Government was not hostile to the Washington Eight Hours' Day Convention, it viewed with concern the possibility of a retrograde movement on the part of the chief industrial Powers towards longer hours. Great Britain intended thoroughly to explore every means of avoiding a movement of that kind which, in its opinion, would be comparable to the competition in armaments that preceded the great war. The principle of a 48-hour week was embodied in agreements covering many millions of workers in Great Britain. Side by side with that had grown up a movement in favour of a five-day week, and there was difficulty in reconciling it with the terms of the Convention. There was also a railway agreement which provided for overtime in a way that made it difficult to adopt the proposals. M. Léon Jouhaux, the French workers' delegate, and Mr. Poulton, the British workers' delegate, both expressed dissatisfaction with the British Government's attitude. The German Government delegate, Herr Feig, stated that only 50 per cent. of the German workers were working more than 48 hours per week.

The Special Delegate Conference of the Miners' Federation of Great Britain, which was held at Blackpool on Wednesday and Thursday last week, rejected the proposal to terminate the present wages agreement. According to the official report of the proceedings, Mr. T. Richards, vice-president, who occupied the chair, mentioned that, on the previous day, the delegates had spent several hours in considering the whole position of the industry and what could be done to improve it,

and the Executive, having given consideration to the discussion, had agreed to recommend a resolution for the acceptance of the delegates. Mr. W. P. Richardson (Durham), treasurer of the Federation, then moved the resolution, which was to the effect that the report of the investigation into the conditions of the coal mining industry be accepted and referred to the districts for their consideration; also that the Committee continue to carry on the further investigations necessary, and report to another conference.

Mr. Richardson said that, on the previous day, the chairman had made the wise statement that this was to be a non-decision conference. Their sub-committee, who were making the investigations, had spent a good deal of time in listening to the woes and troubles of the coalowners. It was only on the last two days of the meetings with the coalowners that the men's representatives had an opportunity of raising the questions upon which they wanted information. The owners had agreed to go into these matters at future meetings. They included the questions of what were capital charges, of working conditions at collieries, the exclusion of trading departments such as coking and by-product plants, and the Russian coal market. The question of payment by Russia for coal sent was not such a difficulty as had been assumed by some owners, as those owners who had supplied coal to Russia had had no trouble in securing payment, but Russia had refused to take our coal, and they were afraid that there was a political reason for the refusal. Therefore, they intended to press that question in order to ascertain the facts, if possible. The Executive had also suggested to the owners that there should be more co-operation with the men in the matter of buying materials and selling products. All these questions would be gone into, and he asked the conference to agree to the continuing of the investigation.

Lancashire proposed, as an amendment, that the Executive Committee be instructed at once to draft proposals for a new wages agreement from the suggestions received from districts, as submitted at the last special conference at Blackpool, and that such draft proposals be submitted to districts with a view to being considered at a special National Delegate Conference to be convened at an early date. A general discussion followed, after which the delegates separated into district groups to determine how their votes should be given. When the conference resumed, the vote was taken, and resulted as follows: For the Committee's resolution, 571,000; against, 230,000; majority, 341,000. The Credential Committee reported that 158 delegates were present, representing a membership of 798,103. South Wales and the Forest of Dean supported the Lancashire resolution.

The one hundred and second quarterly report of the General Federation of Trade Unions contains an interesting reference, by Mr. W. A. Appleton, the Secretary, to the present very unsatisfactory state of British industry. Hopes of spontaneous trade revival have been encouraged, he says, by sections of the press and by certain types of politicians. There is, however, in his opinion, little sign of these hopes being realised in such a way as adequately to relieve the situation or to absorb the unemployed, of whom there are a million and a quarter. "There have been, and there still are," he goes on to say, "demands for legislation to deal with the situation, but legislation can never effectively supersede individual and co-operative effort. The only revival that appears to be feasible or possible, is the revival which follows an understanding of the situation, an acceptance of the facts as they exist, and as they must exist for a number of years, and a united effort, on the part of workmen and employers and legislators alike, to effect such changes and improvements in industrial production and in public administration as will give British workmen a renewed chance of earning a livelihood in competition with the rest of the world. In these circumstances, the Management Committee views with interest the attempts of the employers and workmen in various ways to get together for the purpose of studying the facts and circumstances which militate against commercial expansion, or against the maintenance of old standards of commercial success."

In the *Monthly Trade Report* of the United Pattern-makers' Association it is stated that 800 members of the organisation are unemployed. The total membership is 11,686. The ballot on the Stockton and South Shields proposal to withdraw nationally from the Engineering and Shipbuilding Trades Federation is to be taken next month.

Sir Arthur Steel-Maitland, Minister of Labour, speaking at Birmingham, said that the remedy for unemployment associated with the name of Sir Alfred Mond, though it looked perfectly reasonable on the face of it, would not be, in the opinion of the Government, a good thing for the country in the long run. At the same time, all were grateful to Sir Alfred for putting the proposal forward so that a judgment could be found upon it. A subsidy was only good so far as it created fresh employment. It was obviously no good if it merely took an order from one firm and gave it to another in our own country, and that was what the scheme would do to a large extent. Even as regards foreign orders, British firms competed one with another, and therefore it was only in a small percentage of cases that the plan would work beneficially. Another objection was that the subsidy would tend to help the less efficient firms as against the more efficient, inasmuch as it would, at the start, penalise people who put in new machinery and would prevent firms bringing themselves up to date. In the end it would tend to run right through industry and would prove an intolerable burden. No country was the better for being "doped" and not facing the facts, and the one thing needful to improve trade was the greatest efficiency on the part of both masters and men.

THE NEWCOMEN SOCIETY.—Arrangements have now been made for the holding, at Gloucester, from June 17 to 20, of the summer meeting of the Newcomen Society for the Study of the History of Engineering and Technology. A programme of events has been published, copies of which may be obtained from Mr. H. W. Dickinson, Secretary of the Society, the Science Museum, South Kensington, London, S.W.7, to whom members should intimate, not later than June 10, their intention to attend the meeting.

THE LATE MR. WILLIAM CLARK.—The death occurred, on May 20, of Mr. William Clark, of Eaglescliffe, erecting engineer and senior official on the staff of Messrs. Head, Wrightson and Co., Limited, Teesdale Iron Works, Thornaby-on-Tees. Mr. Clark joined that firm in the year 1867, and during the course of his long association with the company, he successfully carried out large works in various parts of the world. In particular, he was engaged on the erection of the Victoria and Waterloo railway stations, the Dover harbour pier, and the bridges over the Thames at Barnes and Putney. During the last three years Mr. Clark acted in a consultative capacity to Messrs. Head, Wrightson and Co., Ltd.

REAMING AND BORING TOOLS.

THE BIRMINGHAM SMALL ARMS COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

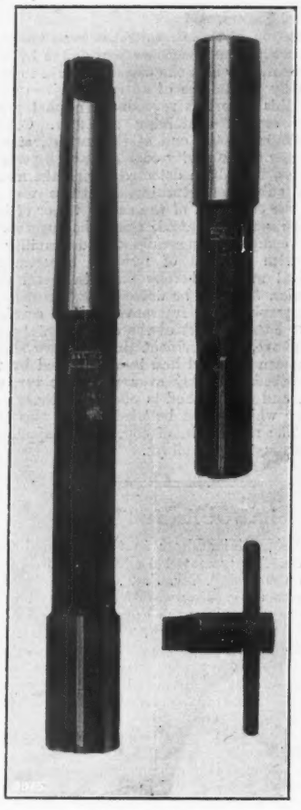


FIG. 1.

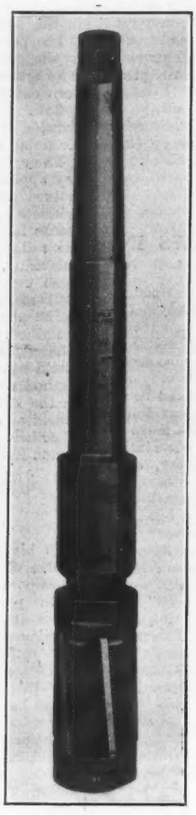


FIG. 2.

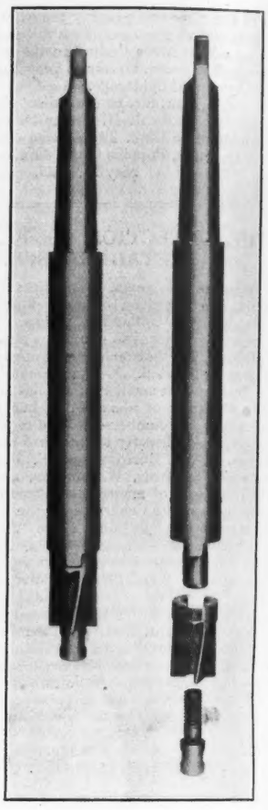


FIG. 3.

REAMING AND BORING TOOLS.

SOME additions which the Birmingham Small Arms Company, Limited, of Birmingham, have recently made to their extensive range of small tools are shown in the accompanying figures. Three types of tool are illustrated—expanding reamers, an inserted-tooth reamer, and counterbores. The expanding reamers, which are particularly useful when holes have to be enlarged to fine limits above standard reamer size, are shown in Fig. 1. The reamers are split and adjustment is made by means of a taper screw in the end, which is set by a key of the type shown in the figure. These expanding reamers, which are made from carbon steel, range in size from $\frac{5}{8}$ in. to $1\frac{1}{2}$ in. The inserted-blade reamer, shown in Fig. 2, is made in a range of sizes from $\frac{5}{8}$ in. to 2 in. The inserted blades are adjusted by means of two cone nuts, which, when securely locked, make the tool as rigid as a solid reamer. The range of adjustment enables the blades to be used until they are really worn out. The accuracy of the reamer is fully maintained until this stage is reached, when new blades may, of course, be fitted to the original shank.

The B.S.A. counterbores illustrated in Fig. 3 consist of three parts—a shank, a cutter, and a pilot—as shown to the right of the figure. One shank is made from each group of sizes and all cutters and pilots in each group are standard, so that a large number of combinations of counterbores are possible with one shank. The tools are made from high-speed steel and range in size from $\frac{3}{4}$ in. to 3 in. In addition to the tools illustrated, the Birmingham Small Arms Company have just introduced a new design of quick-change drill chuck. The chuck is fitted with pawls, which are held in engagement with the tool or released by an outer sleeve. The sleeve can be moved while the chuck is revolving. The design of the pawls is such that the load due to the driving of the tool is distributed over a large area, both on the inner face which engages with the tool and on the outer face, which engages with the sleeve. The chuck may be easily taken to pieces, and all parts are interchangeable. The body has a standard Morse taper shank.

SOME TESTS ON A TWO-STROKE CYCLE OIL-ENGINE.*

By PROFESSOR E. A. ALLCUT, M.Sc., of the University of Toronto.

DURING the last few years the two-stroke cycle heavy-oil engine has advanced considerably in popularity for installations where the demand for power is too small to be met satisfactorily by the Diesel engine. Such engines are usually supplied with crank-case compression, and their advantages and disadvantages have already been fully discussed in various publications, so that the main characteristics of this type of engine are well known.

The following tests were made to investigate the behaviour of a two-cycle engine under different loads, to ascertain the extent of the various heat losses and the various efficiencies. As a suitable oil calorimeter was not readily available for student and laboratory work, the experiments described in Appendices I to III were undertaken with the object of designing such a calorimeter, the result being given in Appendix I.

Test Arrangements.—The tests were performed on a vertical oil engine supplied by Messrs. W. H. Allen, Sons and Co., of Bedford, and installed in the Thermodynamics Laboratory of the University of Toronto. It is the standard type of two-stroke cycle heavy-oil engine supplied by this firm, having hot-bulb ignition and crank-case compression. The single cylinder has a bore of 9½ in., the stroke is 11 in., and the rated power 25 b.h.p. at a speed of 375 r.p.m. The oil is injected into the cylinder at the proper moment by a pump, the stroke of the plunger being regulated by a governor to keep the speed constant when variations of load occur. The general lay-out and many details of the engine and test apparatus will be seen from the photograph reproduced in Fig. 1, while other particulars are embodied in Table I.

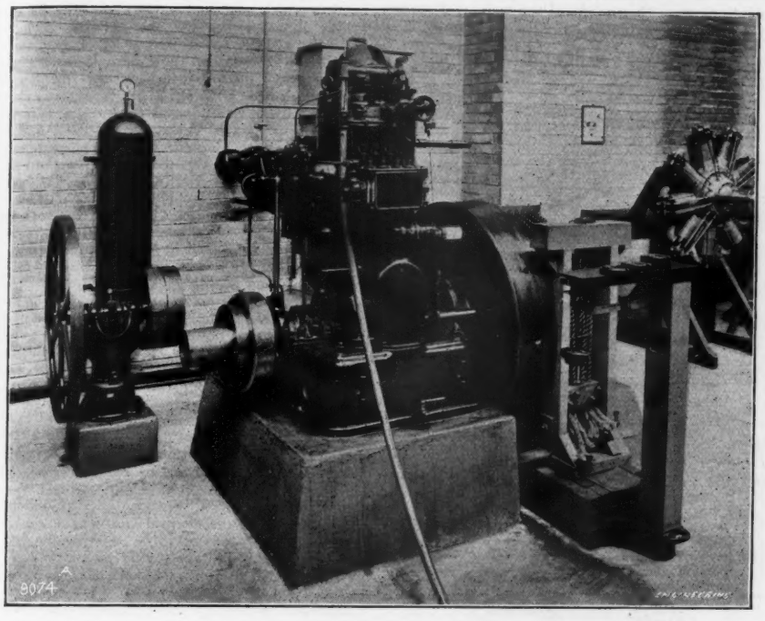
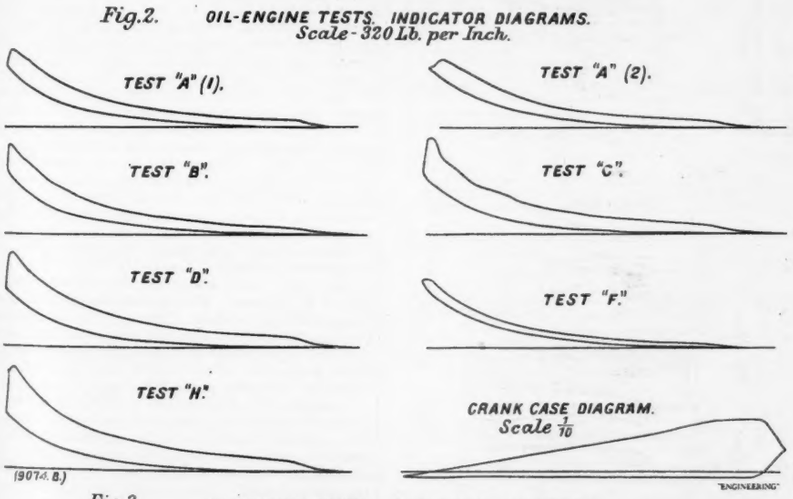
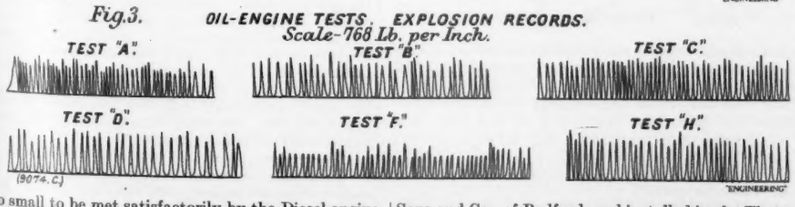


FIG. 1. ARRANGEMENT OF OIL ENGINE FOR TRIALS.





For test purposes the oil was supplied from a tank mounted on a sensitive weighing machine, readings being taken at 10-minute intervals during each test. Curves were plotted from these data, and the rate of oil consumption was found to be constant for each test. In each case the engine was started up on paraffin, was changed over to fuel oil after about 10 minutes, and was run for at least 60 minutes under steady conditions before any readings were taken.

The methods employed for obtaining the calorific value of the oil-fuel are detailed in Appendix I.

A Crosby gas-engine indicator was connected to the cylinder and numerous experiments were made to ascertain the best strength of spring for these conditions, a rate of 320 lb. to the inch being finally selected.* With this the following cards were taken at frequent intervals during each test:—

(*a*) Indicator diagrams for indicated horse-power determinations, Fig. 2.

(*b*) Explosion records to indicate the regularity of combustion, about thirty consecutive explosions being recorded on a time bas for each card, Fig. 3.

(*c*) Light spring diagrams (1/80 spring) for examining conditions at the end of the stroke. Oscillations due to the high speed made it inadvisable to use a lighter spring for this purpose, Fig. 4.

Another indicator was connected to the passage joining the crank-case to the inlet ports, and diagrams were taken at frequent intervals with a spring rated at 10 lb. per inch. A thermometer was also inserted at this point to indicate the mean temperature of scavenging, and owing to the low-compression pressure (3–4 lb. per square inch) and the heavy mass of metal, it is probable that very little cyclical variation of temperature occurs at this point. All springs were calibrated for accuracy by means of a dead-weight gauge-tester.

The brake used was an ordinary rope-brake mounted on a platform weighing machine, and its construction will readily be seen from Fig. 1. No-load tests were made by removing the brake.

The engine ran very steadily throughout and care was taken to keep the load constant during each test, a man being kept constantly at the brake for that purpose. The exhaust temperatures were measured by means of a calibrated Chromel-Copel thermo-couple inserted in the exhaust pipe as close to the engine as possible, and during each test the various of temperature was usually not greater than 10 deg. to 20 deg. F.

A sample of exhaust gas was taken from the exhaust-pipe close to the thermo-couple by means of a small tube closed at the end and drilled with a large number of small holes for the purpose of obtaining a sample as representative as possible. This was taken through a water-cooled spiral, the condensate being collected in U-tubes containing calcium chloride, and the dried gas received in a calibrated gas-holder containing a thermometer and pressure-gauge. The holder had a capacity of 2 cub. ft., and its rate of rise was controlled in such a way that this quantity of gas had accumulated at the end of each ninety-minute test, after which samples for analysis were immediately transferred to glass sampling tubes of the usual kind. The gas analysis apparatus used was that known as Burrell's apparatus, and is described in the United States Bureau of Mines Bulletin, No. 42.

The cooling water was collected in tanks mounted on platform weighing-machines and the inlet and outlet temperatures were measured. The quantity was controlled in each test to give an outlet temperature as near as possible to 135 deg. F. The speed of the engine in all tests was taken every ten minutes on the main shaft by means of a speed counter, and great care was taken to ensure the accuracy of this measurement.

Test Results.—Typical indicator diagrams, explosion records and light spring diagrams are shown in Figs. 2, 3 and 4 respectively, and the various numerical quantities relating to them are given in Table 1. The coefficient n in the formula PV^n = constant varies from 1·13 to 1·04 in the case of the expansion curves, the lower values being characteristic of the heavier loads. The form of the compression curve varies little, the average value of n being 1·33. From the light spring and crank-case diagrams it is evident that the compression curve starts practically from atmospheric pressure at all loads, but a large number of cards indicate oscillations of pressure during the exhaust period, Fig. 4, Tests C, D, H.

This engine is governed by restricting the supply of oil to the cylinder at light loads, and in the no-load test it was observed that frequently no firing took place. If this occurred while indicator diagrams were being taken, the pencil was kept on the paper until a diagram was obtained, and the mean effective pressure

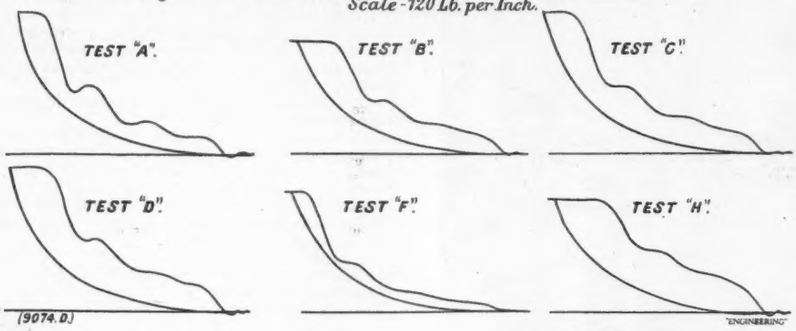
* Paper read before the Institution of Mechanical Engineers on Friday, May 22, 1924. Abridged.

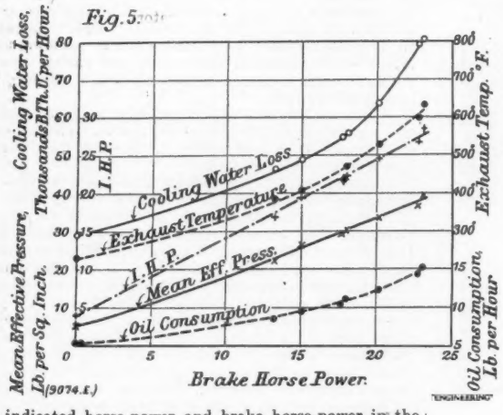
* Attempts were made to reduce pencil friction by taking the diagram on smoked celluloid and paper, but the results obtained were no better.

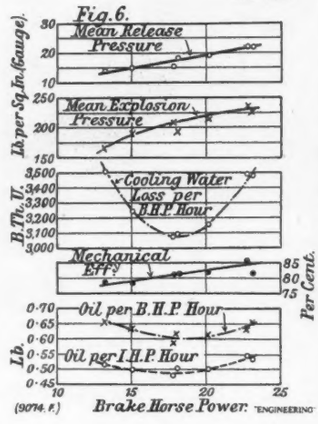
worked out for all these diagrams in the usual way. The explosion records were then used to establish the ratio of firing to total cycles, and the figure obtained by multiplying the mean effective pressure already obtained by this factor was considered to be the true mean effective pressure at no load.

In this test the percentage of "misses" was 64·4 of the total number of cycles, and the indicated horse-power thus obtained was 4·02. Deducting 1·48 for crank-case compression, the net indicated horse-power was 2·54, a value very close to the differences between

Fig.4. OIL-ENGINE TESTS. LIGHT SPRING DIAGRAMS. Scale - 120 Lb. per Inch.







indicated horse-power and brake horse-power in the other tests.

At heavy loads the combustion is practically at constant volume, but at light loads many cards show slow combustion on account of the poorness of the charge (c.f. Fig. 2, Test "A" 2). A number of preliminary tests were made before the present series, and in these it was observed that late ignitions frequently occurred. The injection was therefore advanced about 6 deg., the fuel consumption in the present series being less than that in the preliminary tests as follows:—

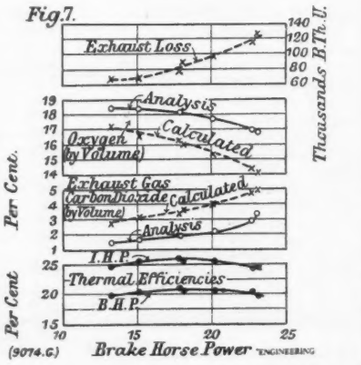
Test	A	C	D	E
Reduction in oil consumption	Per cent. 14	Per cent. 8·5	Per cent. 7·5	Per cent. 0

After this adjustment had been made no late ignitions were observed on any of the diagrams.

The mechanical efficiencies vary from 78 to 85 per cent. and the thermal efficiencies from 24 to 27 per cent., Table 1, and Fig. 6. In the calculation of the loss of heat to exhaust, allowance was made for the heat lost in supplying kinetic energy to the exhaust products leaving the cylinder immediately after the uncovering of the ports. For this purpose, a "fill efficiency"* of 0·6 was used and adiabatic expansion through the ports assumed. As the total amount of heat thus dissipated is comparatively small (3 to 4 per cent.) no great inaccuracy is likely to arise from these assumptions. The amount of heat unaccounted for in the heat balance varies from 8 to 10 per cent. This includes radiation and any oil escaping unburned through the ports. No carbon monoxide was detected in the exhaust gases in any of the tests.

In the no-load test, however, this discrepancy is large, and it is fairly evident that when explosions are missed oil is delivered to the cylinder in insufficient quantity to form an explosive mixture, and thus the fuel escapes through the ports. This would account for the large percentage of missing heat.

The exhaust analyses obtained in the manner already described present some features of interest. The first set of analyses showed low percentages of carbon dioxide, and on investigation this was found to be due partly to the presence of free lime in the calcium chloride used for drying purposes. This was remedied, and the analyses shown in Table 1 were obtained. Calculations were then made of the weight of carbon delivered to the engine and the weight leaving it as



shown by the exhaust analyses, and the following Table shows the percentage of carbon accounted for by the exhaust gas analyses:—

Test	A	B	C	D	E	G	H
Percentage of carbon accounted for	Per cent. 51·3	Per cent. 50·5	Per cent. 53·4	Per cent. 52·8	Per cent. 60·7	Per cent. 51·7	Per cent. 67·7

This discrepancy is due to the fact that the first puff of exhaust gas leaving the cylinder at a high velocity is comparatively rich in carbon dioxide, and as the sample is collected at a constant velocity, the proper proportion of carbon-rich gas does not appear in the sample. For this reason Table I and Fig. 7 are supplemented by corrected values of carbon dioxide and oxygen content, obtained by calculation from the weights of air and oil delivered to the cylinder per cycle and assuming complete combustion. The other results contained in Table 1 and plotted in Figs. 5, 6 and 7 are self-explanatory, and do not call for particular comment.

(To be continued.)

* Illmer, "Porting and Charging of Two-Stroke Engines," A.S.M.E. 1921.

CLAY CONVENTION AT BUXTON.

AMONG the bodies taking part in the Clay Convention which was held at Buxton from Tuesday to Friday of last week, was the Ceramic Society, the Refractory Materials Section of which held its spring meeting on Tuesday at the Palace Hotel. There was a large attendance of members, and the proceedings were commenced with Mr. J. Holland in the chair. A proposal from the Council to form a new district consisting of North Yorkshire, Durham, and Northumberland was adopted, and three members were elected to represent this district on the Council. Mr. Frank West, of the Derbyshire Silica Firebrick Co., Limited, was next elected President of the Ceramic Society, and occupied the Chair for the remainder of the session. It was announced that the autumn meeting would be held at Wembley, and that a visit to Czecho-Slovakia was under consideration for the spring meeting of next year.

The first paper on the programme was on "Manufacture of Magnesite," by Mr. G. H. Reed. In the absence of the author it was taken as read, and will be published in due course in the Transactions of the Society. The paper dealt very briefly with the operations involved in the production of magnesia bricks from raw magnesite, including useful information from practical experience.

Next came a paper of great interest by A. T. Green on "The Heat Insulation of Kilns and other High-Temperature Installations." The loss of heat through kiln walls by conduction, radiation, and convection was considered, and the possibility of reducing the heat loss by means of insulation was discussed. For high temperature work, the satisfactory insulating materials available are chiefly slag wool and diatomaceous earth products, slag wool having a very limited application for such work. Diatomaceous earth (otherwise called diatomite, kieselguhr, or infusorial earth) consists essentially of silica, but most of the natural deposits include impurities such as lime, iron oxide, and clay, which lower the insulating efficiency of the materials to a serious extent. For high-temperature work the essential properties of insulating materials are low thermal conductivity and high porosity. For the successful utilisation of insulating materials a range of 0·00025 to 0·00050 at 400 deg. C. for the coefficient of thermal conductivity forms a satisfactory guide. The high insulating properties of such materials are partly due to the nature and quantity of the pore spaces, the size and disposition of which appear to affect the heat conductivity. It is noteworthy that slag wool, with a porosity of 88 per cent., is a less effective insulator above 450 deg. than diatomaceous-earth brick with a porosity of 75 per cent., the porosity of the latter material being much more minute and disconnected, and also evenly distributed. The range of apparent porosity allowable is 65 to 85 per cent., though most good insulators have values between 70 and 80 per cent. Pure diatomaceous earth retains its porosity up to about 1,250 deg. C., but impurities like lime, iron oxide, and clay may cause vitrification, resulting in shrinkage and great decrease in the insulating properties. Slag wool, it may be noted, is not a reliable insulator above 700 deg. C.

Normally, the temperature gradient in an uninsulated kiln wall is steep, but much less so when insulated. The spalling trouble, so often experienced with uninsulated refractories, especially in many intermittent systems of heating, is mitigated, to some extent, by an insulated wall. Ceramic kilns of various types are capable of improvement by using insulating materials on the crowns and in the walls. Insulating methods are of great use in the iron and steel industry for effecting fuel economy. In modern iron and steel plants, suitable insulation is now used in the blast stoves, and in many reheating and heat-treatment furnaces, producers, &c. The value of insulation is also highly appreciated in the gas industry.

In conclusion, the author points out that the selection of insulating material for high-temperaure work cannot be based on insulating efficiency alone. Before selecting such a material it is absolutely essential to have a complete knowledge of the circumstances of its future use, particularly regarding the face temperature to which it will be subjected. The following data will then serve well in the selection: (*a*) The coefficient of thermal conductivity at temperatures between 300 deg. C. and 800 deg. C., or the insulating efficiency based on a test simulating industrial conditions; (*b*) the percentage porosity, with some description of the nature of the pore spaces; (*c*) the refractoriness (i.e., the specification test), with the temperature at which the material disintegrates or otherwise loses its

SOME TESTS ON A TWO-STROKE CYCLE OIL ENGINE.

TABLE I.

Constants :—Compression volume, 129·7 cub. in. (0·075 cub. ft.). Stroke volume, 778 cub. in. (0·45 cub. ft.).
Compression ratio, 5·8. Crank-case volume, maximum, 2·387 cub. ft. Crank-case volume, minimum, 1·937 cub. ft. I.H.P. constant for 1 lb. m.e.p. and 1 r.p.m. 0·001975. Air-cycle efficiency, 51·3 per cent.

Test No.	A	B	C	D	E	F	G	H
Duration of test minutes	90	90	90	90	90	90	90	90
Atmospheric conditions—								
(a) Barometer .. .. inch	29·82	29·48	29·80	29·50	29·48	29·50	29·76	29·76
(b) Wet bulb thermometer .. deg. F.	77	74·5	78·5	74·4	77	74·5	75·8	78·3
(c) Dry bulb thermometer .. deg. F.	84	80·5	86·5	79·2	82	86	80	83·4
(d) Humidity .. .. per cent.	73·2	77·2	70·0	80·3	80·2	58·6	82·6	80·2
(e) Lb. water per lb. dry air	0·0188	0·0175	0·0194	0·0174	0·0191	0·0160	0·0184	0·0198
Fuel Quality—								
(a) Sp. gr. at 74·8 deg. F.	0·849 (Average sample)	—	—	—	—	—	—	—
(b) Viscosity	See below (Appendix)	—	—	—	—	—	—	—
(c) Cal. value (higher)	B.Th.U. per lb. 19,850	—	—	—	—	—	—	—
(d) Cal. value (lower)	B.Th.U. per lb. 18,715	—	—	—	—	—	—	—
(e) Carbon .. .. .. per cent.	85·45	—	—	—	—	—	—	—
(f) Hydrogen .. .. „	13·01	—	—	—	—	—	—	—
Flash point, 186 deg. F. Flame point, 202 deg. F.								
Fuel quantities—								
(a) Weight per hour .. .. lb.	8·71	9·52	10·44	12·27	14·40	5·28	11·07	15·14
(b) „ per b.h.p. hour .. .. „	0·656	0·631	0·586	0·609	0·633	—	0·613	0·655
(c) „ per i.h.p. hour .. .. „	0·516	0·494	0·476	0·499	0·541	1·313	0·498	0·533
Speed, revolutions per minute	382·1	370·0	380·7	370·6	367·3	380·5	373·3	364·3
Brake horse-power	13·27	15·08	17·81	20·15	22·74	—	18·04	23·10
Indicator diagrams—								
(a) Mean explosion pressure .. lb.	164	190	209	214·2	235	—	192	225
(b) „ compression pressure .. „	128	128	28	128	128	128	128	128
(c) „ release pressure .. .. „	13·8	14·8	15·2	18·8	21·6	—	17·9	21·9
(d) „ effective pressure .. „	22·40	26·45	29·20	33·6	36·70	5·35	30·16	39·50
(e) Gross i.h.p.	16·89	19·28	21·95	24·59	26·63	4·02	22·24	28·40
(f) M.E.P. crank-case .. .. lb.	1·91	1·85	1·79	2·15	2·03	1·97	2·19	2·23
(g) Maximum pressure crank-case „	3·65	3·50	3·60	3·80	3·70	3·60	3·80	3·90
(h) I.H.P. crank-case	1·44	1·35	1·34	1·57	1·47	1·48	1·61	1·60
(k) Net i.h.p.	15·45	17·93	20·61	23·02	25·16	2·54	20·63	26·80
Mechanical efficiency .. .. per cent.	78·5	78·4	81·2	81·9	85·5	—	81·2	81·3
(a) Temperature in crank-case deg. F.	102	99	104·5	99·5	103·3	101	98·4	103·6
(b) Suction in crank-case .. .. lb.	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3
Heat removed by cooling water—								
(a) B.Th.U. per b.h.p. .. per hour	3,503	3,234	3,076	3,151	3,486	—	3,087	3,475
(b) B.Th.U. per i.h.p. .. „	2,752	2,530	2,496	2,574	2,977	7,117	2,504	2,826
Exhaust gases—								
(a) Temperature in exhaust pipe, deg. F.	385	405	435	525	598	230	470	630
(b) Temperature after cooling, deg. F. ..	81·4	79·5	79·7	—	78	—	77·1	75·1
(c) Gas collected in holder cub. ft.	1·98	1·685	1·81	1·96	1·815	1·63	1·85	1·85
(d) Exhaust loss, B.Th.U. per hour	66,520	69,180	78,550	97,480	115,190	—	88,900	127,180
(e) Analysis by volume—								
CO_2 .. .. .. per cent.	1·40	1·59	1·80	2·11	2·86	0·7	—	3·33
O_2 .. .. „	18·43	18·25	18·10	17·70	16·90	19·9	—	16·73
CO .. .. „	—	—	—	—	—	—	—	—
N_2 .. .. „	80·17	80·16	80·10	80·19	80·24	79·4	—	79·94
Efficiencies, &c.—								
(a) B.Th.U. consumed .. per hour	172,890	188,970	207,230	243,560	285,840	104,810	219,740	300,530
(b) B.Th.U. per b.h.p. .. „	13,028	12,531	11,629	12,086	12,570	—	12,180	13,010
(c) Thermal efficiency on b.h.p. basis, per cent.	19·50	20·27	21·83	21·00	20·21	—	20·87	19·53
(d) B.Th.U. per i.h.p. .. .. hour	10,236	9,801	9,441	9,904	10,732	26,072	9,880	10,581
(e) Thermal efficiency on i.h.p. basis, per cent.	24·79	25·89	26·87	25·63	23·64	9·74	25·69	24·00
Heat balance per cent.—								
I.H.P. equivalent	24·79	25·89	26·87	25·63	23·64	9·74	25·69	24·00
Cooling water	26·88	25·81	26·44	26·07	27·73	27·30	26·70	26·71
Exhaust	38·48	36·61	37·91	40·00	40·30	62·96	40·45	42·31
Radiation and unaccounted for	9·85	11·69	8·78	8·30	8·33		7·16	6·98
Volumetric efficiency of pump, per cent. ..	79	77·8	77·1	78·8	79·2	74·8	80	81·2
Corrected analysis (by volume) of exhaust gases (calculated)—								
CO_2	2·75	3·15	3·4	4·03	4·75	—	3·54	4·93
O_2	17·20	16·55	16·25	15·35	14·40	—	16·00	14·12
N_2	80·05	80·30	80·35	80·62	80·85	—	80·46	80·85
Mean value of "n" (expansion)	1·12	1·11	1·12	1·10	1·06	1·12	1·13	1·04
„ „ (compression)	1·334	1·334	1·334	1·334	1·334	1·334	1·334	1·334

structure ; (*d*) the crushing strength as an indication of the mechanical strength.

At this stage, "A Note on the Structure of a Fused Fireclay Crucible," by Mr. W. J. Rees, B.Sc., F.I.C., was taken as read. It will be published in the Transactions of the Ceramic Society, with the other papers.

The next item was a paper by Mr. W. Hugill, B.Met., and Mr. W. J. Rees, B.Sc., F.I.C., on "The Effect of Repeated Burning on the Structure and Properties of Lime-Bonded Silica Bricks." The bricks were reburned 11 times, and the results, which are collected in tables and graphs, indicate the great importance of the "soaking" period of the burn, more especially in the first burn, when the greater part of the inversion of the quartz took place. Very little change in volume resulted after the first burn. The porosity decreased steadily to the seventh burn, but afterwards remained fairly constant. Crushing strength increased up to the seventh burn. A gradual increase of toughness after the sixth burn was noticeable.

An important and well illustrated paper by Mr. T. F. E. Rhead, M.Sc., A.I.C., and Mr. R. E. Jefferson, M.Sc., A.I.C., of the Birmingham Gas Department, formed the next item on the programme. It was entitled "Notes on : (1) Testing for Refractoriness and After-Contraction ; (2) A Few Experiences with Refractories in Vertical Retorts." In the first part of the paper the authors discuss the difficulties sometimes met with in carrying out standard tests for refractories, particularly with respect to the suitability of some of these tests for materials intended to be used under specially severe working conditions, such as those which exist in retort settings, &c. The Gas Engineers' Specification for Refractoriness, first adopted in 1912 and revised in 1922, still allowed different observers to obtain substantially different test results, and, with a view to obviating this, a further modification is now proposed. "A definite size of cone ground to the same shape as a Seger cone, with one edge perpendicular to the plane of the base, is heated with the base horizontal to the specified Seger cone, taken from the furnace and examined with a straight edge to see whether its shows signs of bending—this bending, or matrix running out, constituting the definitions of signs of fusion. The rate of heating and oxidising are as before." It is proposed to call this "The Gas Engineers' Refractoriness Safety Test," to save confusion with the better-known squatting test.

From a routine testing point of view, for commercial use, there are several advantages to be gained by adopting the above safety test in place of the squatting test, viz. : (1) It shows the softening of the material at a somewhat lower temperature than the squatting test. (2) With the squatting test it is very difficult to judge from the appearance in the furnace whether or not the material is being overheated, and a second test is often necessary. (3) By stopping the heating of the test piece, at the minimum specified cone, the wear and tear on the furnace is minimised. (4) It is considerably easier to stop a test at a given temperature when using a series of Seger cones than to stop when the test piece itself shows signs of bending, rounding, or tip touching base ; this is because of the additional information given by the behaviour of the other Seger cones of the series. (5) The correct rate of heating during the last 100 deg. C. to 200 deg. C. is a matter of considerable difficulty, especially with a gas-heated furnace. This difficulty is increased the higher the temperature to be attained, owing to the diminishing head of heat between the flame temperature and the test piece.

The chief signs of fusion which can be detected by the naked eye are : (1) Glazing of surface ; (2) bending of test piece ; (3) swelling ; (4) loss of angularity of edges ; (5) matrix running out ; and (6) flowing. From numerous tests in different laboratories it appears that, with fireclay, silicious, and silica refractories, a suitably shaped test piece, heated under specified conditions, begins to bend, or the matrix runs out, either before or as soon as the other signs of fusion appear—with the exception of surface glazing. Mere surface glazing could not be held to represent failure. The refractoriness safety test has two important functions : (1) It determines whether a material has any claim to be classed as a refractory when tested under certain standardised conditions. (2) Being a moderately rapid test, it gives the purchaser a fairly reliable check as to the constancy of quality of refractories received from any particular maker. The after-contraction test is probably the most important test in the present specification, throwing light on the correctness or otherwise of the heat treatment given to the refractory by the manufacturer. The correct interpretation of this test has been shown to be full of pitfalls. It is questionable whether determining the after-contraction at the one temperature of 1,410 deg. C., in accordance with the specification, is sufficient with certain refractories *e.g.*, the composite fireclay-silica brick.

The second part of this paper, as indicated by the title, relates to experiences of interest chiefly to those connected with the gas industry.

A second paper by W. Hugill, B.Met., and W. J. Rees, B.Sc., F.I.C., on "The Influence of Iron Oxide and Iron Sulphides on the Rate of Quartz Conversion in Commercial Silica Brick Manufacture" was taken as read. The paper may be summarised as follows :—

Iron sulphides are normal constituents of the lower coal measure ganisters, but occasionally thick incrustations of these sulphides—marcasite and pyrites—occur, and silica bricks prepared from this pyritic ganister were compared with others made from normal ganister. Occasionally also acicular crystals of barytes (heavy spar) are associated with incrustation of iron sulphides. The chemical composition of the bricks scarcely differed appreciably except that the iron oxide in the bricks from pyritic ganister was 0·5 per cent. more (1·21 to 0·71) than in the bricks from normal ganister. Lime emulsion was added to give 1·5 per cent. of lime in the bricks. The results of tests for true specific gravity, porosity, compression strength, transverse breaking load, and modulus of rupture showed that the pyritic incrustation, instead of being detrimental, resulted in bricks with a higher degree of quartz conversion with the same heat treatment, as well as greater mechanical strength.

Similar effects were noticed in the case of certain bricks contaminated with iron through wear of the bottom of the grinding pan. On the other hand, by using ganister which had been treated with a warm mixture of nitric and hydrochloric acid to remove iron and its compounds, it was found that the rate of quartz conversion and the mechanical strength were both reduced in the absence of the iron oxide.

(To be continued.)

ELECTRIC POWER STATIONS.—A list of the principal central stations of the United Kingdom showing the voltages of supply, system, cycles, and prices per unit has been published by Messrs. S. Rentell and Co., Limited, 36, Maiden-lane, W.C. 2, at the price of 1s.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.*

By M. EUGÈNE BRILLIÉ.

(*Concluded from page* 622.)

Thermo-Pneumatic Transmissions.—The transmission of energy from the motor to the wheels may be effected by compressed air or gas; by this method it is possible to construct a locomotive, the wheels of which are driven by an ordinary locomotive engine, the cylinders being supplied with air compressed by a motor-driven set. In order that such a machine may have a sufficiently high efficiency, it is necessary that the compression should be as nearly isothermal as possible, and that the air should be reheated between the compressor and the working cylinders by means of the heat rejected in the exhaust of the compressor engine. The air may enter the locomotive cylinders at a temperature of 600 deg. or 660 deg. F., and exhaust at a temperature of 120 deg. to 210 deg. F.

Mr. Fausto Zarlatti, an Italian engineer, has made a trial of this method, using an ordinary steam locomotive frame and engine; the boiler being replaced by a Diesel engine driving a compressor. With the object of reducing the work of compression, the suction air was mixed with some of the steam produced by waste heat from the Diesel motor. These trials, which were made in 1923 on the Rome-Northern line, showed the practical possibilities of the method. Another Italian engineer, Mr. Cristiani, has designed a locomotive on a similar principle, but in this case the transmission is effected by the agency of steam, which is used in a closed cycle through the compressor, the reheater, and through the working cylinders back to the compressor.

The Maschinenfabrik Augsburg-Nürnberg has built a Diesel locomotive with compressed air transmission. According to the German description, the arrangements adopted for compression, reheating and working were such that nearly 100 per cent. of the horse-power at the compressor crankshaft was put to use. The Berliner Maschinenbau A.G. exhibited a locomotive of similar arrangemen, at Seddin, which they had built in conjunction with the Gorlitz Company. It is shown in Fig. 84 on this page. The transmission in this case uses the exhaust from the Diesel motor, cooled before compression, in place of atmospheric air. This arrangement was doubtless adopted with a view to taking advantage of the steam contained in the gases derived from the combustion of the hydrocarbons. This locomotive is fitted with a six-cylinder Diesel engine, running at 500 r.p.m., and developing 220 h.p.; it is capable of giving a tractive effort of 3·6 tons at the draw-bar, and of running at 30 miles per hour. The working pressure varies from 120 to 220 lb. per square inch. The driving controls are the same as on an ordinary steam locomotive.

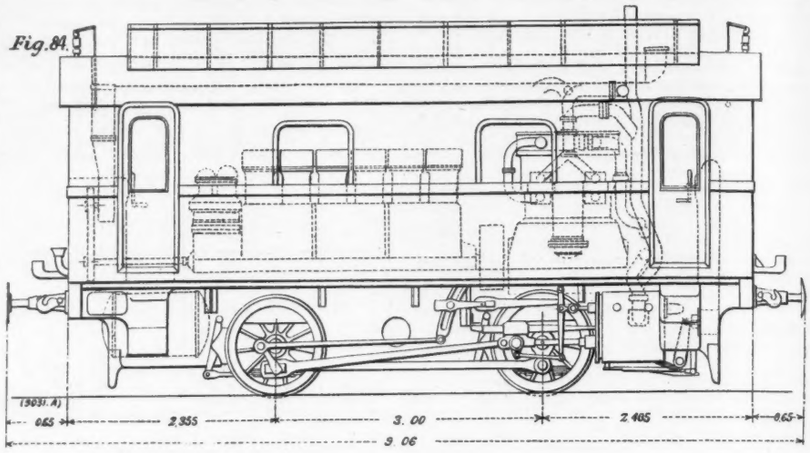
In the same class there is now under construction at the Armstrong Works in England a very powerful locomotive (1,000 to 1,200 h.p.) designed by the Russian engineer, Mr. Schelest, for the Russian Government. Like that previously mentioned, this one is fitted with a Diesel engine driving an air compressor, but the compressor is only required for supercharging the Diesel engine. Instead of taking its suction air from the atmosphere, it is charged with air already compressed to 150 lb. per square inch. The pressure during combustion reaches 900 lb. per square inch, and the exhaust takes place at a pressure of 150 to 180 lb. per square inch into a receiver which supplies the locomotive cylinders. The motor consequently runs with a high back pressure, and only supplies the power necessary for running the compressor. It may be stated, generally, that, although the results of this method of working are not yet known, transmission by air or gas compressed and reheated before entering the working cylinders is a perfectly rational process, and one that may give good results in practice.

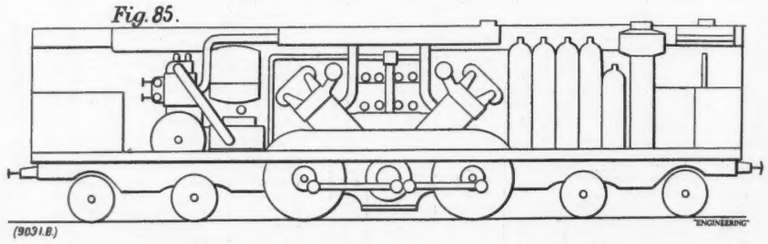
Direct-driven Locomotives.—Attempts have been made to use the combustion motor for driving the wheels of the locomotive directly, as in the case of steam, but this problem is rendered difficult by the trouble involved in starting, because it is not possible, as in the methods that have just been described, to set the engine running and then engage the transmission gear. The direct drive requires the use of an auxiliary source of power adequate for starting the train and the motor simultaneously until a sufficient speed has been attained to enable the combustion engine to take up the load.

The Sulzer locomotive, of 1,000-h.p., which ran its tests in 1913 on the Zurich-Romanshorn line, and was subsequently delivered to the Saxon Railway for which it had been built, is illustrated in Figs. 85 and 86. The engine is arranged transversely between the frames and is of the V-type, 2-cycle, with four cylinders. The two-throw crankshaft forms a dummy axle and drives the wheels by means of coupling rods. The starting is effected by means of an auxiliary set consisting of a 250-h.p. Diesel motor-compressor set supplying compressed air to the driving cylinders of the main motor. The latter works with compressed air until a speed of 6 to 8 miles per hour has been obtained, which is necessary to enable it to work as a Diesel engine. The weak point in this arrangement is the great difficulty in starting under conditions that involve a heavy starting effort, such as exists on an up-grade for example. The cooling of the cylinders by expansion while working as a compressed-air engine also serves to increase the ignition trouble.

The Leroux automotor vehicle, constructed on similar lines to the foregoing, with assistance from the Fives-Lille Company, has been built for use at the Carvin mines. The engine is carried on the leading bogie of the vehicle, and drives the four driving-wheels direct by coupling rods; it is a 2-cylinder, 2-cycle, Diesel engine with cranks at 180 deg., and opposed pistons in each cylinder; each upper piston is connected by diagonal rods to the lower piston of the other cylinder, so that the pistons in each cylinder move in opposite directions, the arrangement being similar to that of the Camellaird-Fullagar engine. Two scavenging pumps arranged alongside are coupled with cranks at 90 deg.; the scavenger pumps are of tandem type with multiple compression up to 900 lb. per square inch for the injection air. A reservoir of compressed air is used for starting, but instead of being used in the combustion cylinders as in the locomotive already described, the air is used in the scavenge cylinders. The valve gear is arranged so that the machine works as a double-acting motor, and, consequently, there is no dead point.

The exhaust air passes into the combustion cylinders, and scavenges them. Under these conditions, the





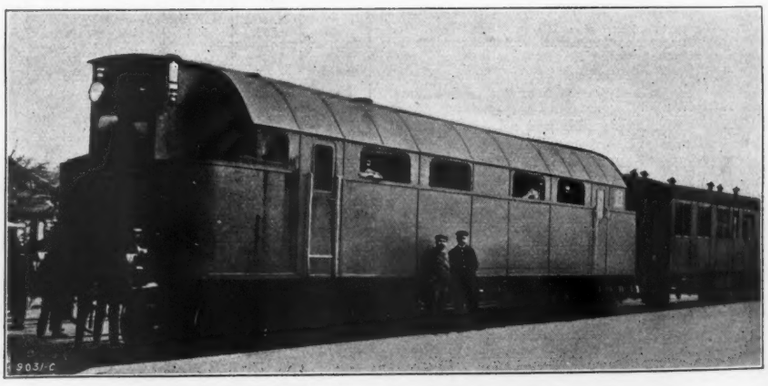
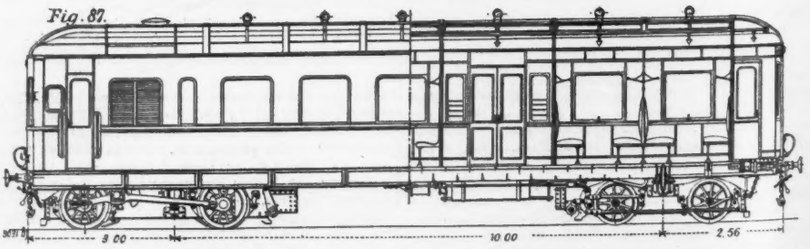


FIG. 86. 1,000 H.P. SULZER DIRECT-DRIVE LOCOMOTIVE.



* Paper read before the British Section of the Société des Ingénieurs Civils de France on April 1, 1925. Abridged.

driving cylinders are supercharged, which improves the conditions when starting to run on the combustion cycle. The installation is supplemented by a small motor-driven compressor for providing the initial storage of air in the bottles, and also by an air reheater arranged in conjunction with the exhaust box, when the engine is running, this appliance stores heat which is to be used for reheating the air required for the next start. This engine has cylinders 200 mm. bore by 250-mm. stroke, and is capable of developing 150-h.p. The weight of the automotor vehicle empty is 24·5 tons, and its consumption of fuel when hauling a train of a total weight of 62 tons is 1·7 lb. of oil per mile or 2·75 lb. per 100 ton-miles. This vehicle, which was running in 1914, was destroyed during the German occupation. It is illustrated in Figs. 87 to 89.

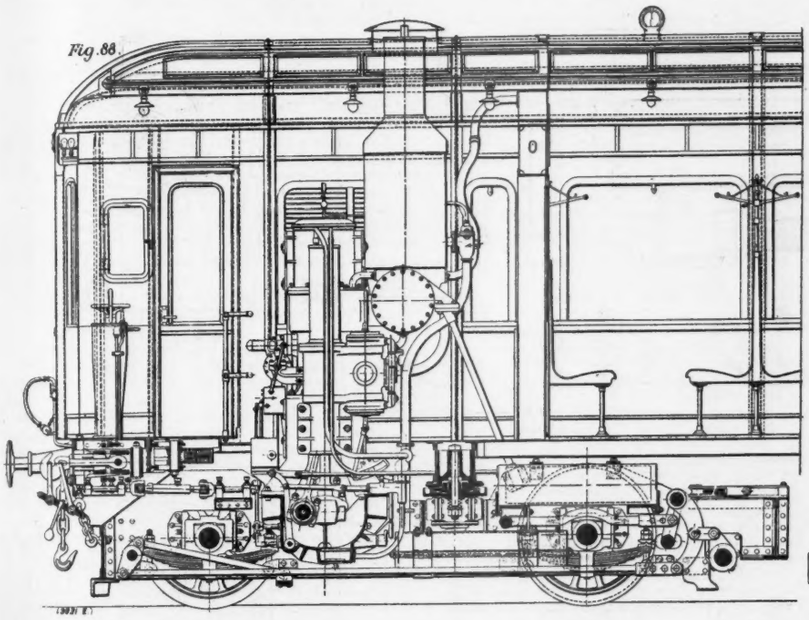


Fig. 88.

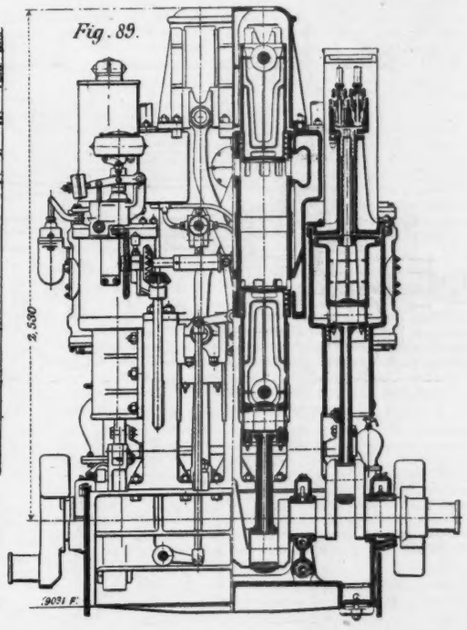


Fig. 89.

The Still System.—This is a mixed steam and internal-combustion arrangement which has already been adopted for marine engines. It works on the following principle: the waste heat of the combustion-motor cycle is used to generate steam, and, with this object the water-jackets of the cylinders are placed in communication by a thermo-syphon with a boiler; the boiler is fitted with a group of tubes through which the exhaust gases pass. A firebox may be used for steam raising, but the gases produced by combustion give up their waste heat to the boiler; it is fitted with burners using the same oil as is used in the internal-combustion engine. The steam that is produced acts on the under side of the driving piston, and it is used to start the engine. A diagrammatic view of the arrangement as applied to a 2-cycle motor, is shown in Fig. 90. The general advantages are as follows: the cylinders, which have been warmed to between 350 deg. and 390 deg. F. before starting to render ignition easier, and thus allow the compression pressure to be reduced to 300 or 380 lb. per square inch in place of 480 lb. per square inch required for starting from cold.

The use of high temperature cooling water reduces the sudden variations in temperature of the cylinder walls. It gives more uniform expansion of the metal parts, which is favourable to the efficiency of the engine and the preservation of the material of which it is made. The steam acting on the under face of the piston cools it; and the regenerative effect of the heat which would otherwise be lost, effects a considerable saving in fuel. In the application of this principle to the locomotive, the boiler enables the train to be started by means of steam, and it can give assistance on heavy banks or when high speed is required; it can supply steam for the whistle, the brake pump, or the brake ejector, and for heating the trains in winter. Actually, the boiler is of small power and simple construction. Two large engineering manufacturers, Kitson's of Leeds, and Schneider's in France, have agreements with the Still Engine Co. and are at the present time constructing or designing locomotives on this principle, but of very different types.

The locomotive of 1,000 horse-power now being made by Messrs. Kitson & Co., Ltd., is shown in Figs. 91 and 92. The motor-unit consists of eight horizontal cylinders working as a 4-cycle combustion engine and driving a 4-throw crankshaft*; the outer surfaces of the pistons are acted on as in an internal combustion engine, and the steam acts on the inner surfaces of the piston as shown in Fig. 90. The crankshaft drives a dummy axle through gearing, which in turn drives the locomotive wheels by means of coupling rods. The boiler has a cylindrical fire-box, with regenerative tubes arranged between the fire-box and the boiler shell. The locomotive has a calculated weight of 70 tons.

The arrangement adopted by Messrs. Schneider and Co. is shown in the Figs. 93 and 94. The engine is a 4-cylinder, 2-cycle vertical engine arranged in front of the boiler. The pair of engine cylinders on each side drive a rocking arm, the shaft of which projects outside the frame, and carries a hanging arm which drives the connecting rod. The arrangement of the

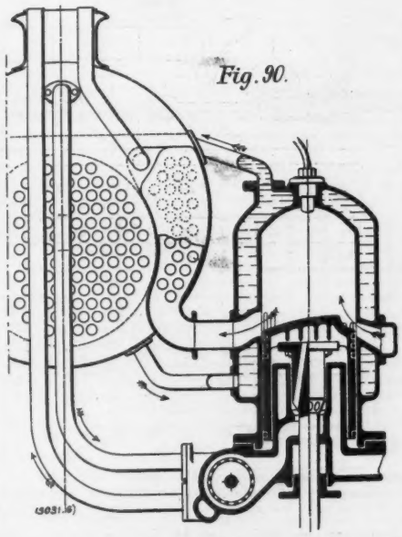


Fig. 90.

piston is slightly different from that shown in Fig. 90. The connecting rods driving on to the horizontal arms of the rocking lever have their small-ends attached to gudgeon pins in the pistons, and are enclosed in a trunk running through a stuffing box. The steam consequently acts on the annular surface of the piston. The piston head is cooled by oil circulation in the same manner that has been applied in some submarine motors. Scavenging is effected by uncovering the ports by means of the oscillating valve controlling exhaust, and produces a slight supercharging of air in the motor cylinder. The cylinders are in communication with the boiler by a thermo-syphon similar to that of the Still-Kitson locomotive. The adoption of the 2-cycle engine dispenses with the valve, but the cylinder capacity becomes about half of that of the 4-cycle engine, consequently the use of steam for providing the starting effort may not prove adequate. To get over this difficulty an arrangement has been made to use the steam on both sides of the piston during starting. The steam for this is supplied by another pipe system with suitable control valves operated by compressed air. The leading dimensions of this locomotive are as follows: cylinders, bore 450 mm., stroke, 500 mm.; diameter of driving wheels, 5 ft. 2 in.; maximum load per axle, 16 tons (this figure is that specified for the Tunisian Railway). The characteristic curves shown in the diagram figure 95, give the power and the tractive effort at the wheel periphery according to the conditions of working. It will be seen that the starting effort and also the tractive effort with steam (burners lighted), require that the four axles should be coupled. The calculated weight of the locomotive is about 76 tons. Provision is made for carrying 550 gallons of fuel and 850 gallons of water, sufficient for a run of 300 to 370 miles with a train weighing 250 to 300 tons. The burner is fitted with a pilot light to enable it to be relighted while the locomotive is running. The driving controls are arranged so that the locomotive is very simple to drive.

It should be noted that the direct drive gives rise to characteristics and working conditions that differ greatly from other methods. The hydraulic electric or pneumatic transmissions which merely transform the energy, give the characteristic of working at constant power, and consequently a tractive effort inversely proportional to the speed. With the direct drive the tractive effort is approximately constant; the power varies with the speed, which is disadvantageous at slow speeds. This difficulty is overcome by the Still engine, as shown on the diagram, Fig. 95.

Summary and Remarks.—The somewhat incomplete list given shows the field of development that these methods of traction are now taking, particularly in foreign countries, and it also shows the great variety of methods that are on trial. In considering the question of rail-cars and of light trains, the greater relative importance of wind resistance must not be lost sight of, particularly at high speeds. This effect is much more serious in the case of the light train; thus, in trials carried out on the French State Railway, the specific resistance at 37 m.p.h. for a rail-car train weighing 25 tons (rail-motor vehicle and trailer) was found to be 1 per cent. of the weight, whereas in the case of a train weighing from 300 tons to 400 tons, it was less than 0·4 per cent. It follows that the rail-car train will only have a low fuel consumption at low speeds up to 30 m.p.h. Some companies have nevertheless put high-speed auto-motor vehicles into service, having reduced their wind surface by the adoption of narrow or tapered ends; but it is necessary to remember that it is the trailing part of a streamline surface that has the greatest importance in the reduction of wind resistances, and that a rail-motor

* A single cylinder experimental engine is now on the test bed for trial.

vehicle built to streamlines would lose the advantages of this form when hauling one or more trailers. In the case of railway motor vehicles, the tendency in Germany and the United States is to use 150 h.p. to 200 h.p., generally with two motors.

In adapting the various methods mentioned, some consideration is required. For low powers all existing transmission methods can be applied, and the selection is chiefly a question of convenience and cost. In the case of rail-motor vehicles, in which the fuel consumption is the main factor, mechanical transmission is distinctly to be preferred. Electric transmission nevertheless has its partisans, and becomes of serious importance in the consideration of high-powered schemes. The Thomas mixed electro-mechanical system enables the advantages of both methods to be obtained. Shunting engines, which require to be extremely easy to drive, can use electric or hydraulic transmission gear for powers even exceeding 400 h.p. For small powers, mechanical transmission or mixed transmission such as the Hautier, can also be used. For locomotives running on railways, and of more than 160 h.p. electric transmission is at the present time preferred; the solution it gives is certain, but the gear is heavy. Pneumatic transmission appears capable of competing with electric transmission, but does not reduce the difficulty of weight.

In the case of powerful locomotives of 1,000 h.p., there is no example at present running that can be said to be thoroughly satisfactory. The attempts that have been made, or are being made, are:—(1) The Sulzer locomotive with direct drive, constructed in 1913, which proved defective owing to difficulty in starting. (2) The three locomotives with 1,200 h.p. engines that are being made for the Lamonossof Mission of the Russian Government, for which a sum of 100,000*l.* (at present exchange) has been voted, are: (*a*) the electric transmission locomotive already constructed by the Hohenzollern works; (*b*) the locomotive ordered from the Gomsa works, with mechanical transmission by gearing and magnetic clutches; (*c*) the thermal locomotive now being constructed at Armstrong's works. In spite of the element of risk involved in these methods the attempts may give very valuable information, particularly if the results of the trials form the subject of a report as complete as exists for the first-named. (3) The two direct-driven locomotives of the Still system now being built at Kitson's works in England, and at Schneider's in France.

In considering the general advantages of thermo-traction and in order to make a comparison with steam, it is necessary to consider two cases separately—that of the explosion motor using an expensive fuel, and that of the combustion motor which can burn low-priced fuel. With the explosion motor expenditure is definitely greater for the same tonnage. But when it is a question of reducing the tonnage, and when the saving in staff and the other advantages enumerated previously are taken into consideration, the cost per ton-mile may actually be less. Under the circumstances in which this class of motor is used, it is not a question of competing with steam, but of improving the working of the traffic by a mixed service capable of using both methods to the best advantage. Thus, on a line served by two steam trains a day, for which the cost may be 3 francs per kilometre (say 18*d.*) per mile, it may be advantageous to retain one steam train per day for working a mixed passenger and goods service, and to replace the other train by one or two rail-car services, which will be cheaper (1 franc per kilometre; or, say, 6*d.* per mile), and also faster.

The rail-car of the French State Railway, weighing 28 tons with its trailer, using petrol costing about 1 franc per kilometre, can take the place of a train burning coal, costing about 2 francs per kilometre, and also saves one employee, no fireman being required. The use of petrol rail-cars for any particular case is therefore a question of special investigation.

The case of the combustion engine is different, and its advantages relate particularly to the cost of fuel per mile. Its comparison with steam can be shown as follows: a heavy train weighing 400 tons, hauled by a modern locomotive, requires about 11 lb. to 12 lb. per 100 ton-miles gross, that is, including the locomotive. For trains of less weight, frequently hauled by locomotives of old pattern, the fuel consumption is higher, and may amount to 24 lb. to 28 lb. per 100 ton-miles, and on lines having heavy gradients it may rise to 35 lb. or even 38 lb. per 100 ton-miles. The consumption of fuel on a train hauled by a rail vehicle fitted with a Diesel engine has been given in the report of services working in Sweden, Switzerland, and Tunisia. The figures range from 2·6 lb. to 3·3 lb. of heavy oil per 100 ton-miles. The managements state that these fuel consumptions correspond to an economy of about 50 per cent. as compared with steam for the same tonnage. This figure does not include the other advantages affecting the economic aspect of the problem, such as the elimination of the fireman, the reduction of cost of upkeep, the elimination of risk of track-side fires, and more efficient utilisation of the rolling stock, &c.

Fig. 91.

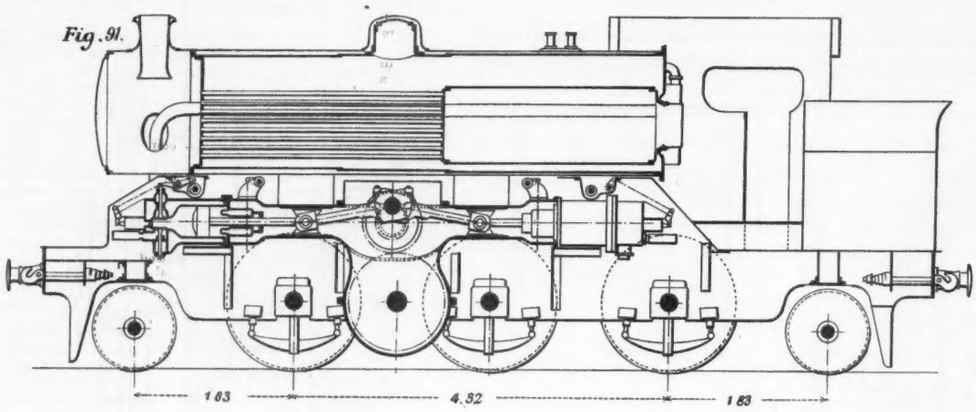


Fig. 92.

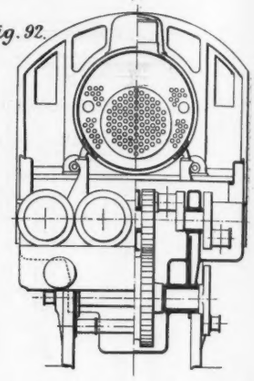


Fig. 93.

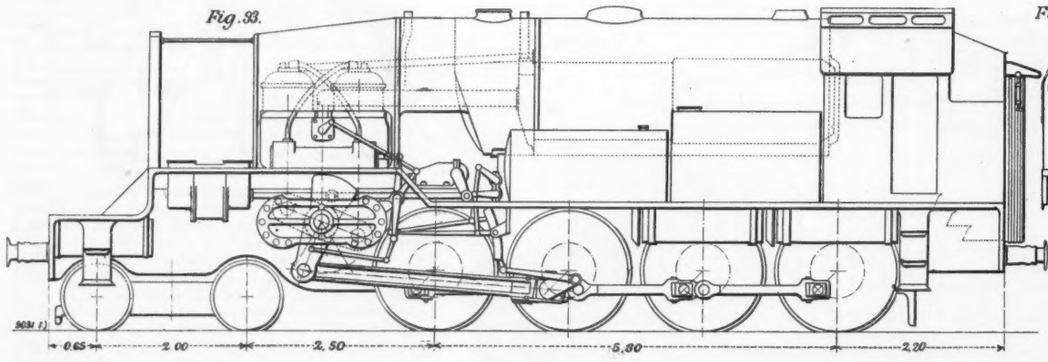


Fig. 94.

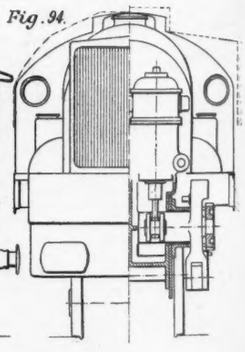
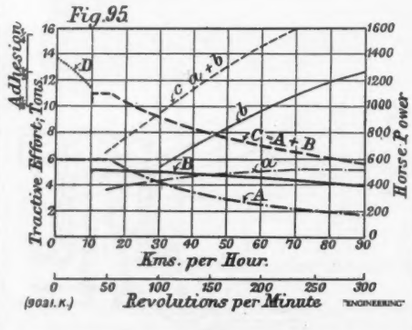


Fig. 95



The question now arises as to what may be expected from powerful locomotives using combustion engines. The Still locomotive will be taken as the first example. If, as a basis of comparison, the mean consumption of electro-Diesel engines of 100 h.p. to 250 h.p., amounts to 2·9 lb. per 100 ton-miles on the average, the following performance may be expected: an increase of efficiency amounting to 30 per cent., due to the use of a direct drive in place of the electric transmission, the improvement resulting from a lower coefficient of traction for a heavy train, and the higher efficiency of the larger engine, which may be assumed to be from 10 per cent. to 15 per cent. The further economy of 10 per cent. which might be obtained by the regenerating effect, due to the mixed steam and internal-combustion arrangement, may be set off against the use of oil in the furnace for raising steam, and occasional use when running. The consumption of fuel oil under these circumstances will amount to about 1·6 lb. per 100 ton-miles, that is to say, from one-sixth to one-tenth that of coal for steam raising, according to the class of train. The corresponding economy may vary from 15 per cent. to 50 per cent., Diesel oil being taken at 62*s.* per ton and coal at 22*s.* per ton (560 francs and 110 francs per ton, respectively), delivered at the depot.

Another aspect of the question is the economic one: the French railways use 10,000,000 tons of coal per annum, of the 25,000,000 tons imported. The electrification programme that relates to 9,000 km. of track, will, when completed, effect a saving of 2,000,000 tons of coal; that is, twenty years hence. The extension of electrification to 18,000 km. will effect a saving of another 2,000,000 tons, which is the limiting figure of the programme. In the not far distant future there will consequently remain some 6,000,000 tons to-

8,000,000 tons of coal to be imported annually for consumption by locomotives. Thermo-traction would enable the expenditure on these imports to be reduced by 30 per cent. to 40 per cent.

Economy in fuel is not the only factor that effects saving, and in addition to the advantages that have been mentioned, it is important to consider the possibility of effecting much longer through runs of 300 miles to 600 miles and over, without taking in fuel or giving special attention to the locomotive, there being no question of removing clinker or cleaning tubes. These conditions might lead to alterations in the organisation of the railway service in the direction of effecting better utilisation of the locomotives and of the staff.

The advantages of traction by the combustion engine are particularly notable in those countries that have either bad water supplies or are themselves oil-producing. On the French Algerian and Tunisian railway systems it is well known that the water is of very inferior quality; it involves expensive purification, and the boilers require frequent repair; in some districts the water is almost unusable.* The new methods will prove very advantageous in this case. The traction question also affects the lines that run through desert regions devoid of water, and particularly the great problem of the trans-Sahara railway, the construction of which is under consideration. Amongst the various schemes at present proposed, the places capable of supplying the necessary quantity of water for the tenders of locomotives are separated by distances of 450 miles to 800 miles. Thermo-traction is certainly the most suitable method for such conditions. Finally, in some of the French Colonies in which it may be possible to produce oil, there is already a demand for oil or alcohol engines not only for automobile traction and industrial purposes, but also for traction on rails.

The combustion engine using gas-oil is partially dependent on the countries that produce petroleum, it can be adapted to the use of vegetable oils, but these oils are costly, and at the present moment cannot compete in France with oils of mineral origin. This state of affairs will not continue. Actually, the increasing consumption of petroleum in the countries that produce it will shortly put a limit on exportation, with the inevitable rise in price, which will occur before the partial failure or complete exhaustion of the supplies.

During this period, other regions suited to the cultivation of oleaginous products may, with improved methods of cultivation, increase their production almost indefinitely. This is the future inexhaustible source of liquid fuel. The French Colonies in Africa and the extreme East may prove the great producers of combustible oil, palm, cotton, copra, castor oil, &c. For this the present primitive methods must be replaced by modern working. In many regions there is no agriculture, and production is obtained by the most rudimentary methods, the only transport being on the human back.† With organised methods, the production could be increased tenfold with the same resources of labour.

A plantation of 2,000 square miles of oil palms is capable of producing a million tons of oil per annum, which is about equal to the French importation of petroleum per annum, and is practically equal to the amount of oil necessary for running all the remainder of the railways that are assumed to be worked by thermo-traction after the electrification of 9,000 km.

From the foregoing it will be seen that the replacement of these importations of oil and coal into France by vegetable oils produced in the French Colonies in the future is by no means Utopian.

The development of thermo-traction on rails appears to be a work of national interest of equal importance to that of electrification, and should contribute equally to the improvement of the exchange. Evolution in this direction should be encouraged. It is in the interests of the shipping companies to encourage all attempts towards the application of these methods.

It is necessary that, in parallel with the efforts of the engineer, the French Colonial Governments should increase their activity with a view to making preparations for the future, in order to provide sources of supply of vegetable oil which will be inexhaustible, and to set France free some day from the necessity of importing the bulk of liquid and solid fuel. It is necessary that French capital should take a less timid part in Colonial enterprise, and that the great business interests concerned with the internal-combustion engine should give them their aid.

* The objection may be raised that in the case of the Still locomotives, the question of the quality of water is as important as in the case of steam locomotives. But as the consumption of water is extremely small, about one-tenth of that in the ordinary locomotive, the use of distilled water would not involve heavy expense. For an expenditure of 2*s.* to 2*s.* 6*d.* per locomotive per day, the cost of washing out the boilers would be eliminated, at the same time that the cost of upkeep would be reduced.

† See the paper by M. Mathot of August 5th, 1923, published in the Bulletin de la Société d'Encouragement. See also the May 1923 issue of "Chimie et Industrie," reporting the proceedings of the Congress on Liquid Fuel of 1922.

CATALOGUES.

Files.—A catalogue received from Sheffield Steel Products, Limited, Sheffield, gives illustrations of the files in general use, with tables of sizes and prices. Many special shapes of files and rasps are dealt with in the priced list.

Printing Machines.—Illustrations of a number of high-speed rotary printing machines are given in a small catalogue issued by the makers, Messrs. R. W. Crabtree and Sons, Limited, Leeds, and 7, Farringdon-road, London, E.C.1.

Oil Engines.—Messrs. Plenty and Son, Limited, Kings-road, Newbury, have issued a bulletin giving particulars of their heavy oil engines developing 50 brake horse power at 300 r.p.m. and made in units of from one to six cylinders.

Rustless Steel and Iron.—Messrs. Hadfield's, Limited, Sheffield, have issued a four-page catalogue briefly describing the uses of rustless steel and rustless iron. Figures are given of the usual test results together with directions for heat treatment.

Gas and Air Meters.—Four types of meters for measuring the velocity or volume of gas or air delivered by blowers, compressors, &c., are shown in a catalogue received from the Steam Fittings Company, Limited, West Drayton, Middlesex.

Electric Plant.—We have received a copy of the quarterly journal of the A.C.E.C., 56, Victoria-street, London, S.W.1, containing articles on turbo-alternators, electric winders, raw materials, &c. The text of the journal is printed in French.

Temperature Regulators, &c.—The Crosby Valve and Engineering Co., Limited, 42, Foley-street, W.1., have sent us a card illustrating temperature regulators for air and liquids, a damper regulator, and a pipe union with inserted bronze seat.

Optical Apparatus.—We have received from Messrs. Adam Hilger, Limited, 75*a*, Camden-road, London, N.W.1, a catalogue describing the apparatus of Benoit Fabre and Perot, for the measurement of the metre in terms of the wave-length of light.

Switchgear.—The British Thomson-Houston Company, Limited, Rugby, have sent us two new catalogues, one dealing with mining pattern, direct-current motor-control pillars and the other with direct-current circuit breakers for tramway service. Both catalogues contain very complete information.

Small Oil Engines.—A description of a Bolinder crude-oil engine developing 6-7 brake horse-power, and suitable for marine or land work, is given in a special catalogue issued by Messrs. James Pollock Sons and Co., Limited, 3, Lloyds-avenue, London, E.C.3, who are the British representatives of the makers.

Lubricants.—Messrs. W. H. Willcox and Co., Limited, 38, Southwark-street, London, S.E.1, have sent us a priced catalogue of their greases and lubricants in various grades, suitable for grease cups, roller and ball bearings, gearing, axles, &c., and including graphite, tallow compound, and high-melting-point greases.

Pumps.—The Aldrich Pump Company, Allentown, Pa., U.S.A., have sent us a general catalogue of their pumps, together with special catalogues of three-throw pumps and portable high-pressure pump units. A considerable amount of technical information, chiefly in the form of tables, is given in these catalogues.

Circuit Breakers.—A new edition of their catalogue containing a table of standard ratings and much illustrated descriptive matter of oil-immersed circuit breakers of medium capacity, including triple and single-pole units, is to hand from the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2.

Electricity Meters.—A catalogue of the Sangamo Ediswan meters has come to hand from the Edison Swan Electric Company, Limited, 123, Queen Victoria-street, London, E.C.4. Standard meters for house service and special meters, such as three-element, switchboard, maximum demand, and portable testing meters, are dealt with.

Preservative Paint.—A small pamphlet catalogue explaining the particular qualities of silica-graphite paint as a protection for wood, iron and steel is to hand from the Joseph Dixon Crucible Company, 22, Duke-street, Stamford-street, London, S.E.1. The natural colour of this paint is dark grey, but it is also made in olive green, dark red and black.

Pipe Fittings, &c.—A catalogue dealing specially with joints, bends, branches, &c., for copper, brass and soft-metal tubes is to hand from the British Steam Specialties, Limited, Fleet-street, Leicester. Particular attention, however, is directed to connections for light-gauge copper tubes, the use of which, in preference to screwed iron and steel tubing, is rapidly extending.

Road Rollers and Traction Engines.—New editions of two catalogues dealing, respectively, with road rollers and traction engines, have been received from Messrs. Marshall, Sons and Co., Limited, Gainsborough. These catalogues contain new matter and give evidence that improvements in design are always being sought for, both with respect to the mechanism and in the matter of fuel economy. A large card with a view of the firm's erecting shop has also been received.

Roofs.—A catalogue of Belfast roofs, which are claimed to be cheaper and stronger than other forms, especially for large spans, has come to hand from Messrs. D. Anderson and Son, Limited, Lagan Works, Belfast, who also have works at Stretford, Manchester and at Old Ford, London, E.3. These roofs are suitable for industrial works, sheds, kilns and similar buildings and are made and erected by the firm.

Small Marine Engines.—The Parsons Motor Company, Limited, Southampton, have sent us copies of three of their sectional catalogues dealing, respectively, with auxiliary yacht installations, yachts and cruisers, and passenger and service launches, fishing craft and commercial craft generally. The contents of the catalogues are chiefly illustrations of the various craft with a few particulars of engine power, speed, capacity, &c.

Type Casting.—The Lanston Monotype Corporation, Limited, 43 and 44, Fetter-lane, E.C.4, have sent us proofs of a fount of 24 point (¼-in.) type cast in three hours on their type casting machine. The type forms over 200 lines each 6 in. in length, and weighs 112 lb. A further copy of the Lanston periodical publication has also been received, and a circular relating to an adding or listing machine.

Reinforced Concrete.—A handbook on reinforced concrete for use by engineers and architects, dealing with methods of calculations, specifications and giving illustrations and descriptions of completed structures has been issued by Messrs. F. A. Macdonald and Partners, 135, Wellington-street, Glasgow. The handbook refers to this firm's system of construction and, in 120 pages of text and illustrations, gives much useful information. It is marked price 5*s.* net.

Warships, Engineering Plant, and Machinery.—An interesting and well-illustrated catalogue has reached us from Messrs. Ansaldo, S.A., Genoa, whose agents in this country and for the colonies are Messrs. Graziani and Co., Limited, 110, Fenchurch-street, London, E.C. 3, showing battleships and other naval vessels, locomotives, large marine engines, land and marine boilers, heavy guns, electric motors, tramway cars, manganese-steel tramway-points, and other products, mainly of the heavy type.

Cane-Sugar Plant.—Two catalogues dealing with machinery for extracting cane sugar are to hand from the Mirrlees Watson Company, Limited, Scotland-street, Glasgow. The first deals with the Searby shredding machine for tearing the cane into a fine fibrous state, and the second with evaporators specially constructed and fitted for circulating and evaporating the sugar solution. Both catalogues contain considerable technical information relating to the parts of the sugar-extracting and refining process to which the machines apply.

Lifting Gear.—Three new publications dealing with hoist blocks and light overhead lifting and carrying cranes, both driven by electric motors; and hand pulley blocks with jib crane, runway or simple supports, have been issued by Messrs. Herbert Morris, Limited, Loughborough, who draw attention to the economy of these appliances in dealing with light loads, as well as with heavy ones. A leaflet has also been received illustrating the construction of the firm's vertical cross-tube boilers which are made in standard sizes ranging from ¾ to 20 nominal horse-power.

IGNITION OF FIREDAMP BY LAMP FILAMENTS.—Tests have recently been conducted by the Bureau of Mines of the United States Department of the Interior with the object of investigating the conditions under which a mixture of methane and air may be exploded by exposure to the heated filament of electric mine-lamp bulbs. Methane, the explosive gas found in nearly all coal mines, is known to be less easily ignited than natural gas, which contains in addition to methane one or more of the higher hydrocarbons, and in the experiments opportunity was taken to observe if the heated filaments which regularly ignited natural gas would also ignite methane, as otherwise the precautions taken in requiring all electric lamps designed for use in mines to be equipped with a safety device were unnecessary. For the purposes of the tests three types of mine lamp bulbs, namely, 2-volt, 0·8-amp., 2½-volt, 1·1-amp., and 4-volt 0·5 amp., were used in conjunction with a 6½-volt, 37-amp.-hr. battery. The gases to be tested were contained in a short iron pipe closed at one end, with a standard pipe cap having a 3-in. diameter glass window ¼ in. thick, and at the other end by a standard pipe flange covered by a circular steel plate. Two apertures were made in this plate for introducing and preparing the explosive gas mixture. A third opening, which was kept covered by a piece of greased parchment paper, served as a relief opening in the event of an explosion taking place. The bulbs were introduced through a threaded opening at the bottom of the chamber and held in position by a special socket. A brass plunger extended through the top of the chamber, vertically above the bulb socket, having an adjustable travel. By adjusting the length of travel, the glass of a bulb could be broken by the plunger without damage to the filament. The procedure in making the tests was to introduce the constituents of the explosive mixture into the test chamber, light the bulbs, record voltage and current readings, and break the glass bulb. In cases where normal or more than normal voltages were used from 50 to 100 per cent. of the broken bulb filaments exploded both methane and natural gas mixtures, thus definitely showing the necessity for bulbs intended for use in mines being protected by some efficient type of safety device.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

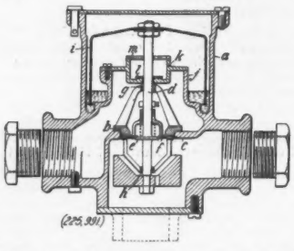
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C.2, at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

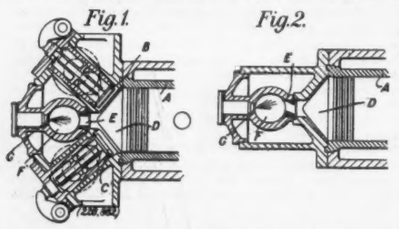
GAS ENGINES, PRODUCERS, HOLDERS, &c.

225,991. E. Dobson, Wimbledon, and Foster Engineering Company, Limited, Wimbledon. Gas Governors. (2 *Figs.*) October 30, 1923.—The invention relates to gas-pressure governors of the kind in which a mercury-sealed bell subjected to the outlet pressure of the gas is employed to regulate the amount of lift imparted to the valve or valves. The gas governor comprises a valve casing *a* having a removable horizontal seating ring *b* mounted in its partition web *c* and a vertically-moving valve spindle *d* carrying pilot and main valves *e* and *f*, respectively, which operate on the lower or pressure side of the seating in regulating the passage of gas to the upper side of the seating. This spindle slides in guides *g* and *h* above and below the



valve seating *b* and is connected at its upper extremity with a mercury sealed bell *i* located in a closed chamber above the gas outlet space. This closed chamber and the gas outlet space are separated by an inwardly-upwardly directed web *j* and an externally-flanged cup-shaped member *k* secured to the upper edge of the web. The valve spindle *d* passes through the cup-shaped member *k*, which, together with washers *l* and *m* closely surrounding, but free to slide with respect to, the spindle and engaging the bottom and the rim of the cup respectively forms a separate chamber more or less isolated from the adjacent spaces. The washers *l* and *m* are capable of sliding with respect to the spindle and fit closely to the adjacent surfaces of the cup member. (*Sealed.*)

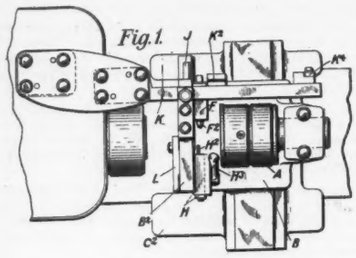
226,862. S. J. Fielding, Gloucester. Internal-Combustion Engines. (6 *Figs.*) September 22, 1923.—The invention relates to internal-combustion engines of the four-stroke type in which the fuel is injected at the end of the compression stroke into a combustion chamber in the cylinder by a comparatively narrow neck inclined to the cylinder axis. According to the invention, maximum turbulence of the charge in the combustion chamber of a four-stroke engine is secured by the combination of the following three features, namely: the inclined disposition of the valves B, C in the cylinder

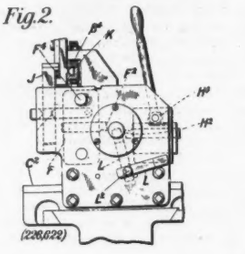


head on either side of the combustion chamber; the inclination with respect of axis of the cylinder of the axis of the narrow passage E connecting the cylinder A with the combustion chamber; and the direction of the fuel jet G in a line across the combustion chamber towards the inlet end of the contracted inclined passage E. Furthermore, in the preferred construction, the contracted passage E is arranged with one wall tangential to or flush with the wall of the combustion chamber at the point at which it enters it, and the outlet orifice to the cylinder A of the contracted passage is preferably offset from the cylinder axis. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

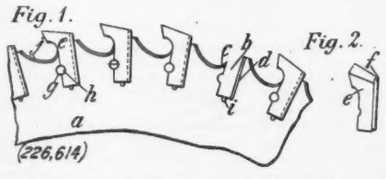
226,622. Sir A. Herbert, Dunley Manor, near Whitchurch, and A. H. Lloyd, Coventry. Metal Turning Lathes. (4 *Figs.*) September 28, 1923.—An attachment for screw-cutting lathes to enable boiler stays, &c., having screwed ends in helical alignment but separated by a reduced plain portion to be produced in one traverse of the slide rest comprises a base B secured to the saddle C2 and provided with a self-opening screwing-die A and a vertical web B2 carrying turning and cutting-off tools F2, H2, respectively. The saddle is traversed by lead-screw having a gap at one end, as described in Specification 152,908, so that the feed will be stopped automatically on completion of the traverse, the die-head being simultaneously opened. When the die-head has screwed the first portion of the stay, an adjustable stop K4 on a bar K depresses a cam plate J, Fig. 2, which oscillates a lever-rest F to position the tool F2 for cutting the reduced portion of the stay, the die-head meanwhile traversing idly. A second





adjustable stop K2 retracts the tool F2, and the die-head then completes the stay. The tool H2 is next operated by a lever, rack and pinion H4 to cut off the stay. The bar K is supported during the traverse by studs B4 of the web B2. In a modification, the turning tool may be fed with and retracted by a hand-operated screwing tool or chaser. A latch L, hinged to the web B2 at L2, may be swung into alignment with the work to act as a stop for the bar feed. A stop F4 limits the oscillation of the lever rest to determine the diameter of the plain portion. The work is supported in a bush D mounted on the web B2 by means of a ball-bearing. (*Sealed.*)

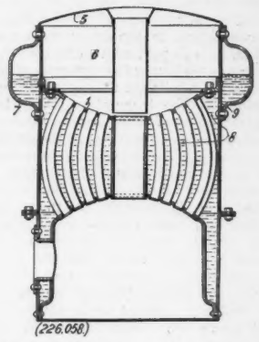
226,614. Edgar Allen and Co., Limited, Tinsley, Sheffield, and R. L. Jackson, Sheffield. Circular Saws and Milling Cutters. (5 *Figs.*) September 26, 1923.—The invention relates to circular saws, milling cutters and the like in which detachable teeth are fitted into gaps in a plate or holder. According to the invention, the plate or holder is formed with gaps according to the number of teeth to be fitted, one side of each gap being flat and the opposite side beingV-edged, the teeth being correspondingly provided with one flat face and one V-grooved face to fit slidably the gaps. *a* is a saw plate provided with gaps *b* having parallel sides. The front side *c* of each gap is formed flat, whilst the rear side *d* is



V-edged. The teeth *e* are made with their front and rear edges to fit correspondingly the gaps, that is, each front edge is flat and each rear edge has a V-groove *f* for the whole depth of the tooth. In the front side of each gap and the front edge of each tooth is a semi-circular recess adapted, when the teeth are in position, to coincide and form a circular hole *g* for the reception of a pin *h* for securing the teeth against movement. In the saw plate at the base of each tooth is a hole *i* to permit the entry of a tool for removing the teeth. The edge of the saw plate *a* between each tooth is cut away or scalloped, as shown at *j*, to give clearance, and this portion is suitably bevelled. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

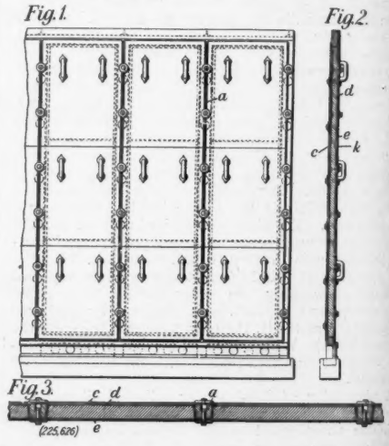
226,058. John Fowler & Co. (Leeds), Limited, Hunslet, Leeds, and W. J. Lewin, Hunslet, Leeds. Vertical Fire-Tube Boilers. (1 *Fig.*) January 22, 1924.—The invention relates to vertical fire-tube boilers wherein the upper ends of the fire-tubes are situated below the water level of the boiler and lead into a smoke or combustion chamber in the crown thereof. According to the invention, the boiler shell is made of uniform diameter at its upper portion or throughout its length with the top tube plates 1 secured thereto at such a distance below the crown plate 5 as to form the necessary smoke or combustion chamber 6 and attached to the upper part of the boiler shell around the smoke or com-



bustion chamber is an annular casing 7 which communicates with the water space 8 of the boiler by way of a series of through holes or apertures 9 in the boiler shell immediately below the tube plate 1. (*Sealed.*)

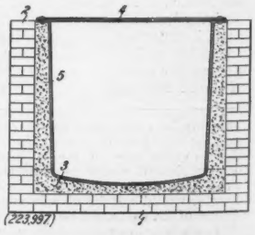
MISCELLANEOUS.

225,626. M. Payne, London, and Hobdell, Way and Co., Limited, London. Insulated Walls. (4 *Figs.*) September 6, 1923.—The invention relates to heat-insulated walls, partitions and the like comprising interchangeable heat-insulated panels fitted into a supporting framework in such a manner that they are independently removable. The wall is constructed as a framework having vertical members *a* which provide between them rectangular apertures into which panels of insulating material are secured.



The framework supports on its inner face an inner covering *c* of insulating material in sheet form. Each panel consists of a slab *d* of insulating material built up on a piece of metal *e* in sheet form which forms the outer covering of the insulated wall, the surface dimensions of the metal sheet *e* being greater than those of the slab *d* so that the metal sheet overlaps the framework members *a* when the panel is in its operative position and also overlaps the outer surface of the panel next in order below as shown at *k* in Fig. 2. (*Sealed.*)

223,997. The New Eccles Rubber Works, Limited, Eccles, and S. W. Cox, Eccles. Storing Corrosive Liquids. (1 *Fig.*) August 3, 1923.—The invention relates to containers for the storage of acids, corrosive liquids and the like. A container, according to the invention, comprises an outer shell or tank 2 of brickwork, a layer of cement 3 upon the bottom of the tank,



a vulcanite container 4 firmly set upon the layer of cement 3 in such manner that the bottom of the container becomes firmly embedded in the layer of cement, additional cement 5 being poured into the cavity between the walls of the container 4 and the outer shell or tank 2, whereby every point of the surface of the container is adequately supported. (*Sealed.*)